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JUNE 2003

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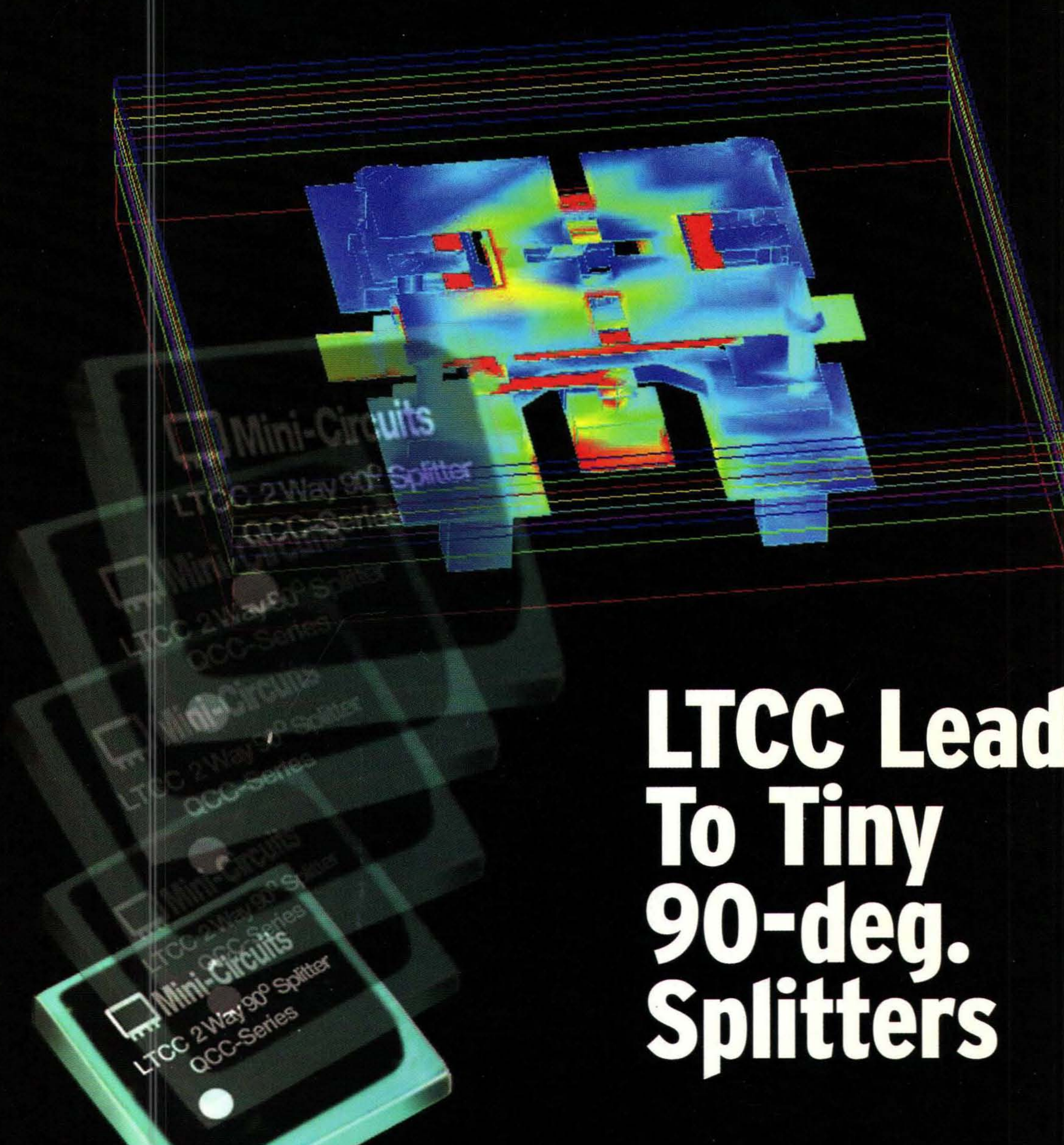
Microwaves & RF

News
An update on Sirenza Microdevices

Design Feature
Designing antennas for UWB applications

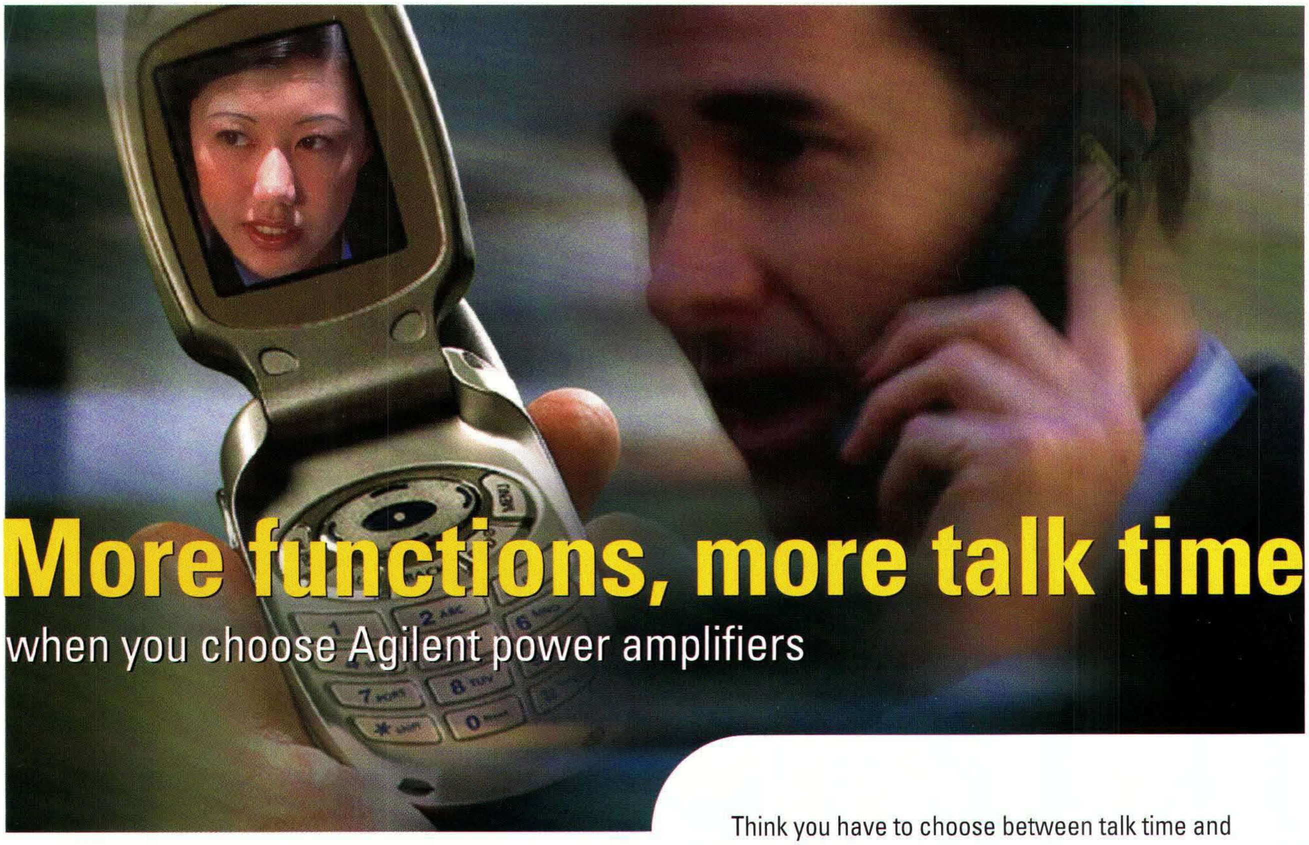
Product Technology
Wideband antennas enhance EMC testing



LTCC Leads To Tiny 90-deg. Splitters

#BXNPGNX *********************AUTO**3-DIGIT 543
#533579017 5# RF 002 100 SCK 387
JOE LORITZ, ENGINEER
GBPPR
424 WILSON AVE
GREEN BAY WI 54303-4115

Defense/Security Electronics Issue



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So whether you're designing for CDMA or GSM standards, don't compromise.... choose Agilent.

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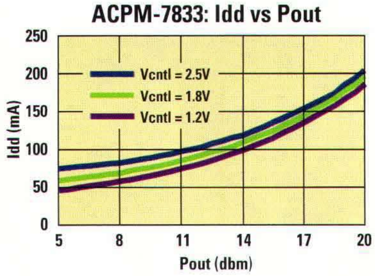
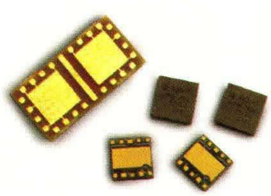
CDMA PAs: Efficiency at Low Vdd

	PAE (%)			
Vdd1 & Vdd2 (V)	3.4	2.0	1.0	Freq (MHz)
ACPM-7833	6.2	10.2	18.2	1880
ACPM-7813	6.1	10.1	18.6	836

Test conditions: Pout = 14dBm Vbias = 3.4V

ACPM-7833: Idd vs Pout





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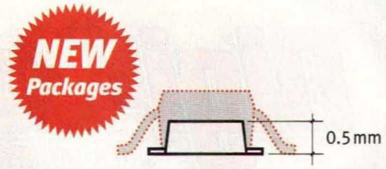
New, Smaller Packages



- **Flat Lead** design reduces parasitics and improves electrical performance
- **Low Profile** is ideal for VCO modules and other space-constrained designs

Oscillators & Buffer Amps

With the best *1/f* performance available, these devices help you achieve the phase noise your design demands. They're also available in Twin Transistors.

Part Number	Corner Freq*	V_{CE}	I_C	Package
NE851M13	1 KHz	1 V	5 mA	**M13**
NE894M13	3 KHz	1 V	5 mA	**M13**
NE685M13	5 KHz	3 V	5 mA	**M13**

**Review Application Note AN1026 on our website for more information on 1/f noise characteristics and corner frequency calculation.*

M13 One sixth the footprint a SOT-323

LNAs

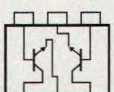
Need low noise and high gain in an ultraminiature package for your hand-held wireless products? These new high frequency NPN transistors deliver!

Part Number	Description	NF	Gain	Freq	Package
NESG2021M05	35 GHz f_T LNA	1.3 dB	11 dB	5.2 GHz	**M05**
NE662M04	23 GHz f_T LNA	1.1 dB	16 dB	2 GHz	**M04**
NE687M13	14 GHz f_T LNA	1.4 dB	14 dB	1 GHz	**M13**

M04/M05 Half the footprint of a SOT-143

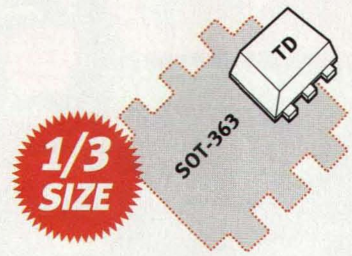
Twin Transistor Devices

Cascode LNAs, cascade LNAs and oscillator/buffer combinations are just three possible uses of these versatile devices. *Matched Die* versions pair two adjacent die from the wafer to help simplify your design, while *Mixed Die* versions — an NEC exclusive — let you optimize oscillator performance while achieving the buffer amp output power you need. Many combinations are available.



One of three pin-outs available

Part Number	Description	Q1 Spec	Q2 Spec
UPA802TC	Matched Die/Cascade LNA	NE681	NE681
UPA895TD	Matched Die/Dual Oscillator	NE851	NE851
UPA861TD	Mixed Die/Osc-Buffer Amp	NE687	NE894
UPA862TD	Mixed Die/Osc-Buffer Amp	NE685	NE851



TD Twin Transistors

Less than one third the footprint of a SOT-363.

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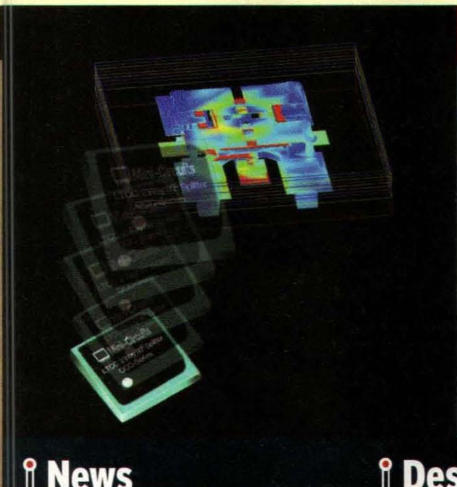

COVER STORY

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Bipolar Amplifiers

Standard Options:

- *Connector Options: SMA, BNC, Type N*
- *Integrated Limiters*
- *Input Bias Tee for Fiber Optic Photodetectors*

OPERATING FREQUENCY (MHz)	MODEL NUMBER	GAIN (dB, Min.)	GAIN FLATNESS (±dB, Max.)	VSWR IN/OUT	NOISE FIGURE (dB, Max.) NF_1	NF_0	NF_2	OUTPUT POWER (dBm, Min.)
0.001 – 500	AU-1534	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 200	AU-1442	35	0.5	2.0:1	1.2	1.2	1.2	+5
0.01 – 200	AU-1447	56	0.5	2.0:1	1.2	1.2	1.2	+12
0.01 – 250	AU-1559	11	0.5	2.0:1	4.2	4.2	4.2	+16
0.01 – 400	AU-1565	54	0.75	2.0:1	1.2	1.2	1.3	+14
0.01 – 500	AU-1310	30	0.5	2.0:1	1.3	1.4	1.5	+8
0.01 – 1000	AU-1402	18	1.0	2.0:1	6.0	5.0	5.0	+16
0.01 – 1000	AM-1300	27	0.75	2.0:1	1.4	1.6	1.8	+8
0.01 – 1000	AM-1431	35	0.75	2.0:1	1.4	1.6	1.8	+8
0.1 – 2000	AM-1364	9	1.5	2.0:1	6.0	6.0	6.0	+10
1 – 200	AU-1464	35	0.5	2.0:1	1.2	1.2	1.2	+6
1 – 400	AU-1421	24	0.5	2.0:1	2.4	2.4	3.1	+17
1 – 500	AU-2A-0150	30	0.5	2.0:1	1.3	1.4	1.5	+8
1 – 500	AU-3A-0150	44	0.5	2.0:1	1.3	1.4	1.5	+10
1 – 500	AU-4A-0150	60	0.75	2.0:1	1.3	1.4	1.5	+10
1 – 1000	AM-2A-000110	26	0.75	2.0:1	1.4	1.6	1.8	+6
1 – 1000	AM-3A-000110	35	0.75	2.0:1	1.4	1.6	1.8	+8
5 – 200	AUP-1568	26	0.75	2.0:1	5.0	4.5	4.5	+28
5 – 300	AUP-1495	11	0.75	2.0:1	15	9.0	9.0	+28
5 – 300	AUP-1496	23	0.75	2.0:1	8.0	7.0	7.0	+28
5 – 300	AU-1021	24	0.5	2.0:1	2.7	2.8	2.9	+20
5 – 300	AUP-1479	36	1.0	2.0:1	2.5	2.7	2.9	+28
5 – 1000	AM-1475	36	0.75	2.0:1	1.4	1.6	1.8	+15
5 – 2000	AM-1573	18	1.5	2.0:1	4.0	4.0	4.0	+21
5 – 2000	AM-1590	36	2.5	2.0:1	3.8	3.8	3.8	+20
5 – 2000	AM-1591	48	2.5	2.0:1	3.8	3.8	3.8	+20
100 – 1000	AM-1412	35	0.75	2.0:1	1.4	1.6	1.8	+14
100 – 2500	AM-1585	26	2.0	2.0:1	3.6	3.6	3.6	+20
200 – 2000	AM-1569	20	1.5	2.2:1	4.2	4.3	4.6	+14
1000 – 2000	AM-1477	37	1.0	2.0:1	1.8	2.1	2.4	+15

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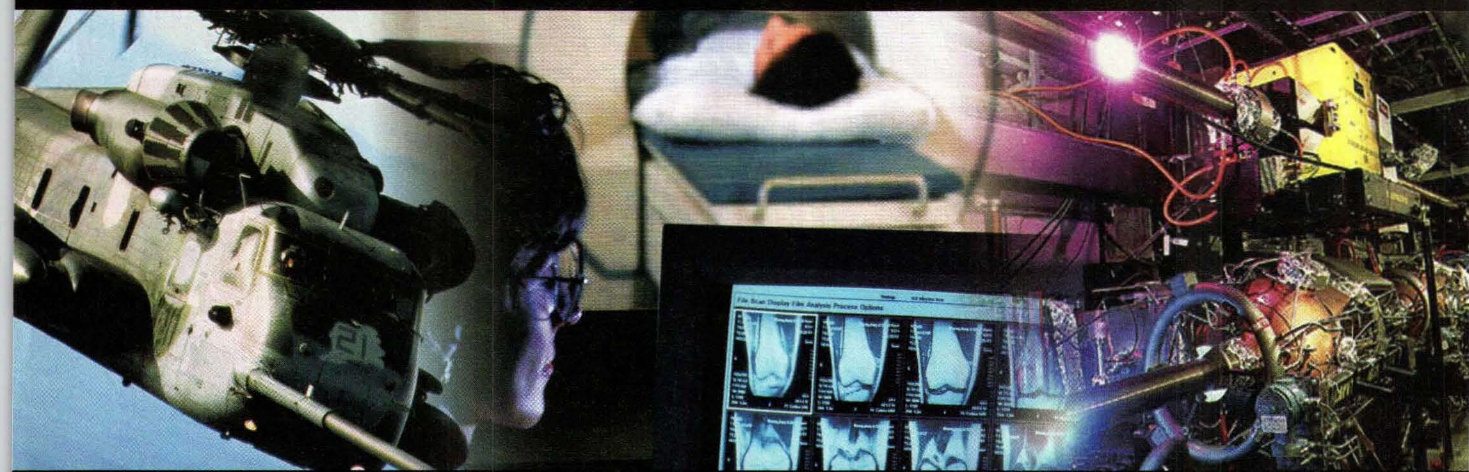

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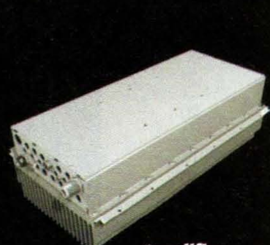
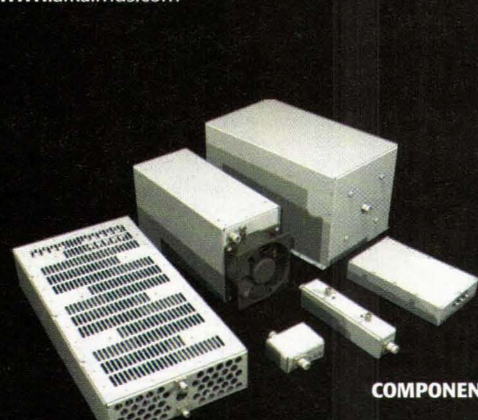
Your Specs...Our Components...To Build an Amplifier That Meets Your Unique Requirements Quickly.

To find out more about the ARKalmus Vision Concept, call us at 425.485.9000 to request a brochure or download one at www.arkalmus.com



Amplifier Module

Amplifier Module



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Article Corrections

I WOULD LIKE to make several corrections to my article, "Meld Load-Pull Tests With EDA Tools," that was published in the April 2003 issue of *Microwaves & RF* (p. 51).

Equation 3 should have read:

$$G + j \times B = \left(\frac{1}{Rp}\right) + j \times \omega \times C$$

The admittance sweep in Fig. 2 is not well depicted as lines of constant conductance.

Contours in Fig. 5 are referenced to a 5 Ω Smith Chart. The Smith Chart in Fig. 10 does not show the resultant locus of points for either Gnet or Gdin.

In addition, my e-mail address was not listed correctly in the article's author contact portion. My correct e-mail address is crc006@email.mpt.com and not @motorola as was stated in the article's author contact portion.

The author regrets the confusion that these errors may have caused and thanks the many readers of *Microwaves & RF* for their constructive comments.

Richard L. Carlson
Motorola
Schaumburg, IL

PLEASE COMMENT

Microwaves & RF welcomes mail from its readers. Letters must include the writer's name and address. The magazine reserves the right to edit letters appearing in "Feedback." Address letters to:

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Publisher/Editor
Microwaves & RF
Penton Media, Inc.
45 Eisenhower Dr., 5th Floor
Paramus, NJ 07652
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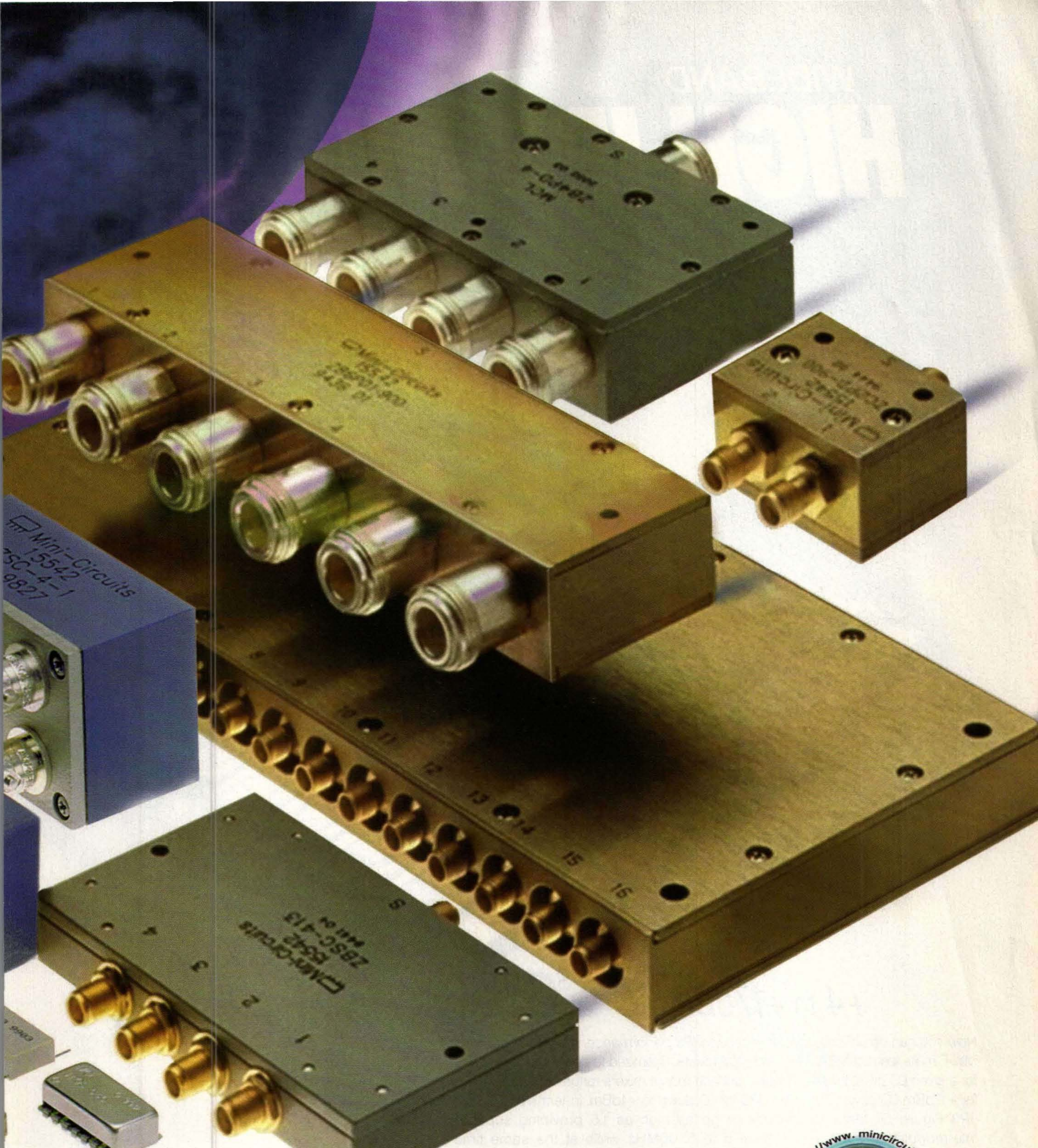
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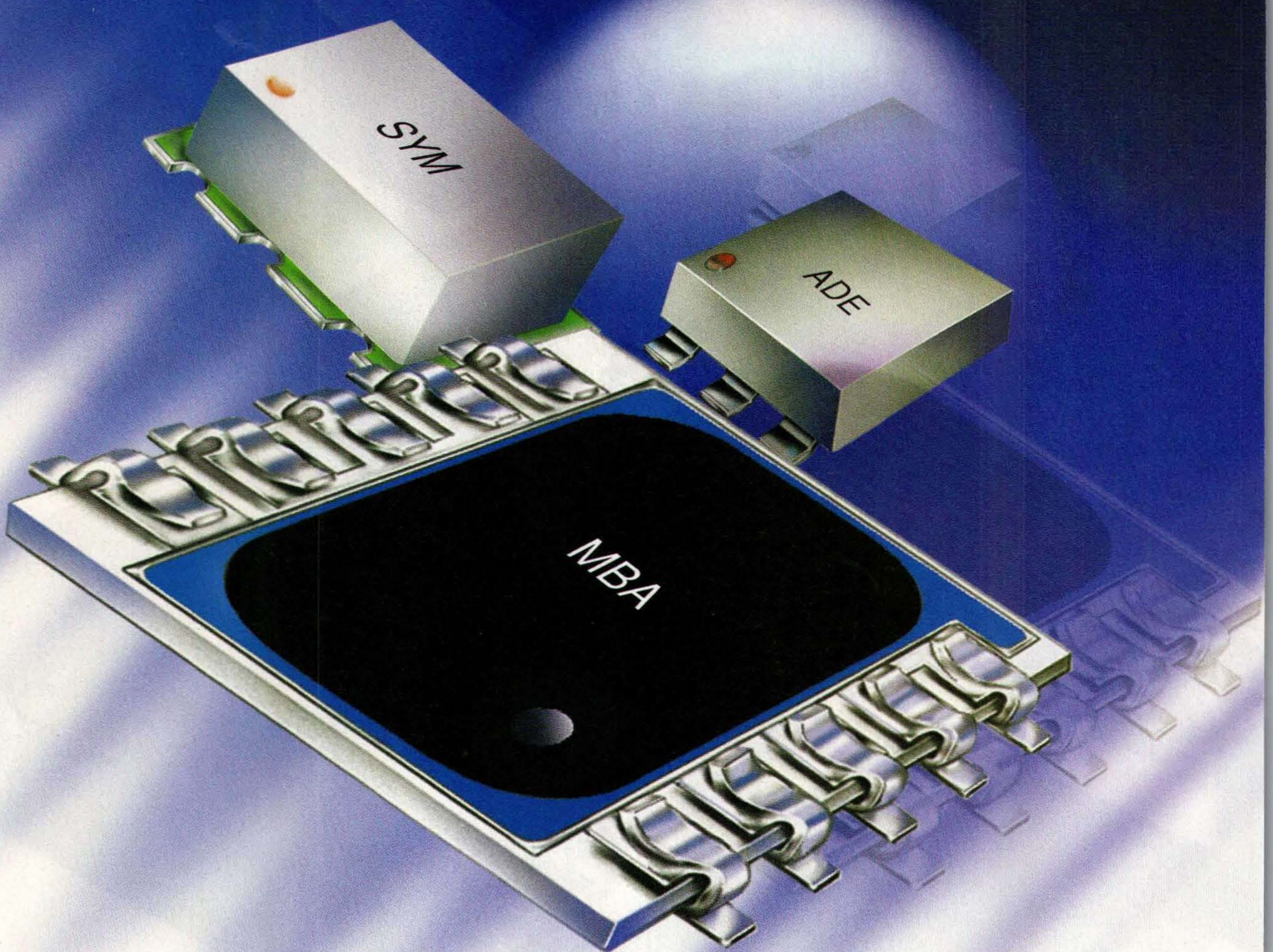
WIDEBAND

HIGH IP3 MIXERS



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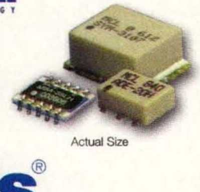
Model	Freq. (MHz)	LO Level (dBm)	IP3 Midband (dBm)	E Factor*	Conv. Loss Midband (dB)	Price $ea. Qty. 10
ADE-10MH	800-1000	+13	26	1.3	7.0	6.95
ADE-12H	500-1200	+17	28	1.1	6.7	8.95
•MBA-591L	4950-5900	+4	15	1.1	7.0	6.95
SYM-25DLHW	40-2500	+10	22	1.2	6.3	7.95
SYM-25DMHW	40-2500	+13	26	1.3	6.6	8.95
SYM-24DH	1400-2400	+17	29	1.2	7.0	9.95
SYM-25DHW	80-2500	+17	30	1.3	6.4	9.95
SYM-22H	1500-2200	+17	30	1.3	5.6	9.95
SYM-20DH	1700-2000	+17	32	1.5	6.7	9.95
SYM-18H	5-1800	+17	30	1.3	5.75	9.95
SYM-14H	100-1370	+17	30	1.3	6.5	9.95
SYM-10DH	800-1000	+17	31	1.4	7.6	9.95

*E Factor = [IP3 (dBm) – LO Power (dBm)] ÷ 10. See web site for E Factor application note.
ADE models protected by U.S. patent 6,133,525.

•MBA Blue Cell™ model protected by U.S. patents 5,534,830 5,640,132 5,640,699.

BLUE CELL™ TECHNOLOGY



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Assess Economics At Trade Shows

PREDICTING FUTURE ECONOMIC CONDITIONS IS a task that often seems a curious blend of economic theory, statistical analysis, and old-fashioned voodoo. One of the most commonly asked questions during plant visits or at trade shows during the last year may be "Do you see things picking up soon?" It is a question that embodies both hope and uncertainty, but conceals a solution that is confoundingly complex. Fortunately, time spent at a trade show can provide a glimpse of the answer.

Military markets are certainly a large part of the microwave industry's tradition.

Whether the opinions on economic forecasting offered at trade shows represent fact of self-fulfilling prophesy, they do provide a fairly reliable sampling of the industry for a given time period. Sometimes, information gleaned from a show in one market can shed light on activities in another market. For example, during a brief visit to the recent Medical Design & Manufacturing East Conference and Exhibition (June 2-4, 2003, Jacob Javits Center, New York, NY), a surprising number of RF/microwave companies could be found among the suppliers of contract manufacturing, coatings, intravenous (IV) components, molding and packaging services, sterilization equipment, and tubing. Some of these companies, such as W.L. Gore (Newark, DE), have been firmly entrenched in the medical equipment industry as long as they have supplied the microwave industry.

Other companies, such as Heraeus (Chandler, AZ), Hypertronics Corp. (Hudson, MA), LEMO USA (Rohnert Park, CA), and Precision Photo-Fab (Buffalo, NY) were there to explore business prospects for their specialties. In all cases, weakening of their traditional markets, largely in electronic materials and connectors, had led them to a quest for new opportunities.

Certainly, a focused show such as the Microwave Theory & Techniques Symposium (MTT-S, June 8-13, 2003, Philadelphia Convention Center, Philadelphia, PA), provides a "safe" and predictable venue for making business contacts. But such a show tends to bring together traditional players in traditional markets, and not the exploratory market "probing" that takes place at a show like MDM East, or an automotive show, or a homeland security event.

Military markets are certainly a large part of the microwave industry's tradition. But these markets have long been ignored by major trade shows. The Military Electronics Show (MES, Baltimore Convention Center, Baltimore, MD, September 16-17, 2003, www.mes2003.com) is an attempt to help microwave companies rediscover markets in the military that may strengthen their economic health. And during a time when this industry is in need of new opportunities, perhaps those old opportunities might do just as well.

Jack Browne

Publisher/Editor

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HIGH-SPEED ELECTRONICS GROUP
Group Publisher Craig Roth, (201) 845-2448 • croth@penton.com
Publisher/Editor Jack Browne, (201) 845-2405 • jbrowne@penton.com
Technology Editor Nancy Konish, (201) 845-2428 • nkonish@penton.com
Managing Editor John Curley, (201) 845-2415 • jcurley@penton.com
Special Projects Editor Alan ("Pete") Conrad
Editorial Assistant Dawn Prior • dprior@penton.com
Contributing Editors Andrew Laundrie, Allen Podell

MANUFACTURING GROUP
Director Of Manufacturing Ilene Weiner
Group Production Director Mike McCabe
Customer Service Representative
Dorothy Sowa, (201) 845-2453, fax: (201) 845-2494
Production Coordinator Judy Osborn, (201) 845-2445

ART DEPARTMENT
Art Director Armand Veneziano • aveneziano@penton.com
Group Design Manager Anthony Vitolo • tvitolo@penton.com

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EDITORIAL OFFICE
Penton Media, Inc.
45 Eisenhower Dr., Fifth floor, Paramus, NJ 07652
Phone: (201) 845-2446, fax: (201) 845-2493

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the front end

News items from the communications arena.

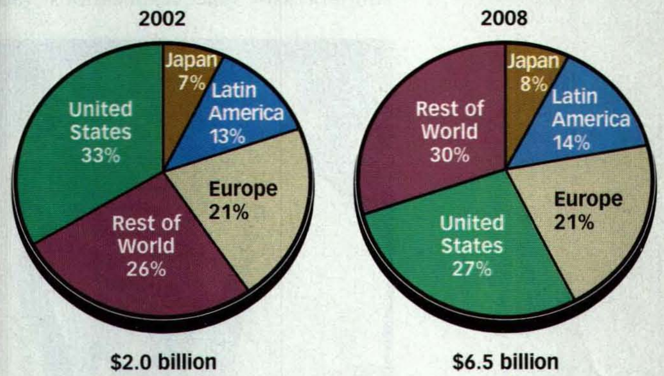
Homeland Security Efforts Are Driving Commercial Telematics Development

OYSTER BAY, NY—The issue of Homeland Security has compelled commercial telematics vendors to develop new, advanced systems and technologies for fleet security applications, including remote vehicle shutdown and biometrics. While these applications are compelling, few fleet operators will initially be able to take advantage of them.

According to "Fleet Management Systems: Exploring Global Market Opportunities, Trends, and Technologies in Commercial Telematics," a report from Allied Business Intelligence, Inc., commercial telematics solutions still lie outside the cost threshold of most small fleet operators, despite dropping hardware costs. Future government subsidies may help finance new telematics systems in some fleets specifically identified to be at higher risk, including transporters of hazardous materials, fuel, and explosives.

"Reaching the virtually untapped smaller fleet markets will be pivotal in driving the global commercial telematics market from $2 billion last year, to over $6 billion in 2008 **(see figure)**," notes Frank Viquez, ABI analyst and author of the report. "Vendors are diligently moving down market to address smaller fleets, however some key issues will present themselves in the near future. The most significant will be a short-term rise in hardware costs for new multimodal telematics hardware that can support not only analog cellular and satellite, but digital communications as well."

Global market value for commercial telematics: 2002 and 2008



Source: Allied Business Intelligence, Inc.
From the study: Fleet Management Systems

EMS Technologies Delivers Antennas For Inmarsat 4

MONTREAL, QUEBEC, CANADA—EMS Technologies, Inc. has announced that the Space & Technology/Montreal division of EMS Technologies Canada Ltd. has recently delivered the Inmarsat-4-L Band Antenna Feeds to Astrium Ltd. in Portsmouth, England.

These antenna feed arrays are designed, manufactured, and tested by EMS Space & Technology/Montreal for the Inmarsat-4 program. The last antenna feed was delivered at the end of April.

The Inmarsat-4 antennas are highly complex, PIM-free, 120-element, combined transmit/receive L-Band arrays. Passive Intermodulation (PIM) is a significant technical issue on any high-power satellite, particularly those that provide mobile satellite services, and the reduction and elimination of PIM is among EMS's core competencies.

The Inmarsat-4 Antennas have been designed to support high-speed (432 kb/s) mobile Internet access, video-on-demand, video conferencing, fax, and e-mail for companies across the Americas. Europe, Africa, and Asia through the INMARSAT Broadband Global Area Network (B-GAN) program.

EMS's L-band antenna feeds are considered to be one of the most challenging subsystems in the INMARSAT B-GAN program. "EMS has a long heritage in high-performance, multi-element antenna feeds for mobile satellite communications, This heritage was a key factor in the selection of EMS to supply these critical spacecraft components," says Dr. Gerry Bush, president of EMS's Space & Technology/Montreal.

ARMMS Conference Informs And Inspires Attendees

CORBY, NORTHAMPTONSHIRE, ENGLAND—The most recent edition of the ARMMS RF & Microwave Society Conference took place on April 7 and 8 at the Hotel Elizabeth in Corby, Northamptonshire, England. The meeting went very well, with 61 people attending from a wide range of areas within the RF and Microwave community. Dominic FitzPatrick of Milmega was the Program Coordinator.

Fifteen papers were presented. The award for best paper was given to Keith Clark of Surrey Satellite Technology for his paper entitled, "Special Considerations for RF and Microwave Amplifiers for Space Applications" **(see photo).**

Program Coordinator Dominic FitzPatrick of Milmega (left) presents Keith Clark of Surrey Satellite Technology with an ARMMS clock as a reward for winning the best paper award at the recent ARMMS RF & Microwave Society Conference.

The ARMMS RF & Microwave Society is an independent professional society comprised of individuals with an interest in the design and measurement of devices and products operating at RF and microwave frequencies. For further information on the ARMMS RF & Microwave Society, see www.armms.org.

Parking Meter Uses Electronic And Mobile-Phone Technologies

CHICAGO, IL—The French company EPARK holds an international patent for a new product to aid in street parking. MobiPark® is an In Vehicle Parking Meter (IVPM) that communicates with a server. This new system allows motorists to pay parking fees directly from their car.

Doing away with traditional parking meters, MobiPark is an electronic device fitted with a communication module that can be adapted for any area served by a mobile-telephone system (GSM, GPRS, CDMA, etc.) or an Internet/wireless infrastructure (WiFi, Bluetooth, etc.). Recharging the device with parking time is done remotely in a fully secured way, thanks to the integrated communication module that handles the e-transaction with the user's bank account or credit card. Payment can also be made with a pre-paid, rechargeable smart card.

Parking enforcement is done through MobiPark's LCD screen, which replaces the usual paper ticket delivered by ticket machines. EPARK's server archives all parking data.

MobiPark enables municipalities to replace obsolete parking meters and protects against the forging of parking coupons.

IP Station Shipments To Exceed Traditional PBX Stations

SCOTTSDALE, AZ—Despite an overall down economy and drops in almost every segment of high tech, LAN Telephony (enterprise VoIP) continued its growth in 2002, with shipments of 60 percent more than the previous year. In-Stat MDR, a high-tech market-research firm, reports that this market is poised to continue its forward mobility, and 2003 will be the year when IP station shipments first exceed traditional private-branch-exchange (PBX) stations.

"This market's size is tied closely to two things—the size of the enterprise voice market and the percent of enterprise voice solutions that migrate to IP," says Brian Strachman, a senior analyst with In-Stat/MDR. "While the overall enterprise voice market is down, the percent of migrations to LAN Telephony is up, resulting in growth, and while few companies are scrapping perfectly good PBXs in favor of an IP system, an increasing number are choosing IP instead of a traditional PBX."

In-Stat/MDR's report, "LAN Telephony 2003: IP or Nothing," studies the overall LAN Telephony market, specific verticals, technology changes, and market drivers. It includes a profile on the products and strategy of all the major vendors, as well as the market shares. It then forecasts revenues for the LAN Telephony market by lines, systems, and revenues, through 2007.

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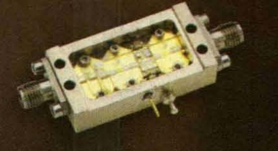
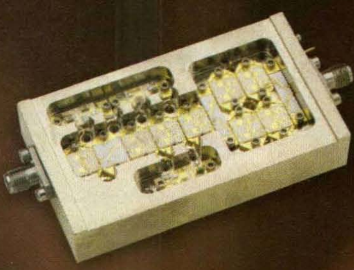
Ultra Broadband Amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA018-204	0.5–18.0	25	4.0	2.5	10	20	2.0:1	300
JCA218-506	2.0–18.0	35	5.0	2.5	15	25	2.0:1	400
JCA218-507	2.0–18.0	35	5.0	2.5	18	28	2.0:1	450
JCA218-407	2.0–18.0	30	5.0	2.5	21	31	2.0:1	500
JCA220-209	2.0–20.0	20	6.0	3.0	20	30	2.0:1	500



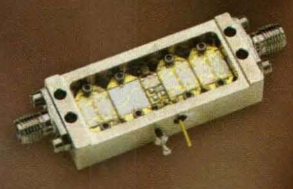
Power Amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-P01	1.35–1.85	35	4.0	1.0	33	41	2.0:1	1000
JCA34-P02	3.1–3.5	40	4.5	1.0	37	45	2.0:1	2200
JCA56-P01	5.9–6.4	30	5.0	1.0	34	42	2.0:1	1200
JCA812-P03	8.0–12.0	40	5.0	1.5	33	40	2.0:1	1700
JCA1218-P02	12.0–18.0	22	4.0	2.0	25	35	2.0:1	700



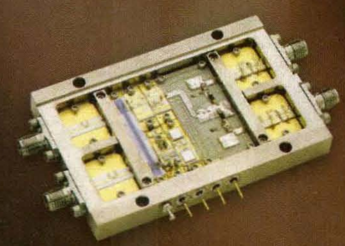
Low Noise Amplifiers

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA12-1000	1.2–1.6	25	0.8	0.5	10	20	2.0:1	80
JCA12-3001	1.0–2.0	40	0.8	1.0	10	20	2.0:1	200
JCA23-302	2.2–2.3	30	0.8	0.5	10	20	2.0:1	80
JCA34-301	3.7–4.2	30	1.0	0.5	10	20	2.0:1	90
JCA78-300	7.25–7.75	27	1.2	0.5	13	23	2.0:1	120
JCA910-3000	9.0–9.5	25	1.3	0.5	13	23	1.5:1	150
JCA1112-3000	11.7–12.2	27	1.4	0.5	13	23	1.5:1	150
JCA1415-3001	14.4–15.4	35	1.6	1.0	14	24	2.0:1	200
JCA1819-3001	18.1–18.6	25	2.0	0.5	10	20	2.0:1	200
JCA2021-3001	20.2–21.2	25	2.5	0.5	10	20	2.0:1	200



Millimeter Wave Amplifiers NEW

Model	Freq. Range GHz	Gain dB min	N/F dB max	Flatness +/-dB	1 dB Comp. pt. dBm min	3rd Order ICP typ	VSWR In/Out max	DC Current mA
JCA2629-201	26.0–29.0	19	5.0	1.5	5	15	2.0:1	100
JCA2629-401	26.0–29.0	35	5.0	1.5	5	15	2.0:1	200
JCA2730-205	27.5–30.0	15	5.0	1.0	15	25	2.0:1	200
JCA2730-302	27.5–30.0	26	5.0	1.0	8	18	2.0:1	150
JCA2730-502	27.5–30.0	43	5.0	1.0	8	18	2.0:1	200
JCA3031-102	30.0–31.0	18	5.0	1.5	8	18	2.0:1	100
JCA3031-302	30.0–31.0	34	5.0	1.5	8	18	2.0:1	200
JCA3031-405	30.0–31.0	40	5.0	1.5	15	25	2.0:1	400
JCA2640-301	26.5–40.0	30	5.0	2.5	0	10	2.0:1	160



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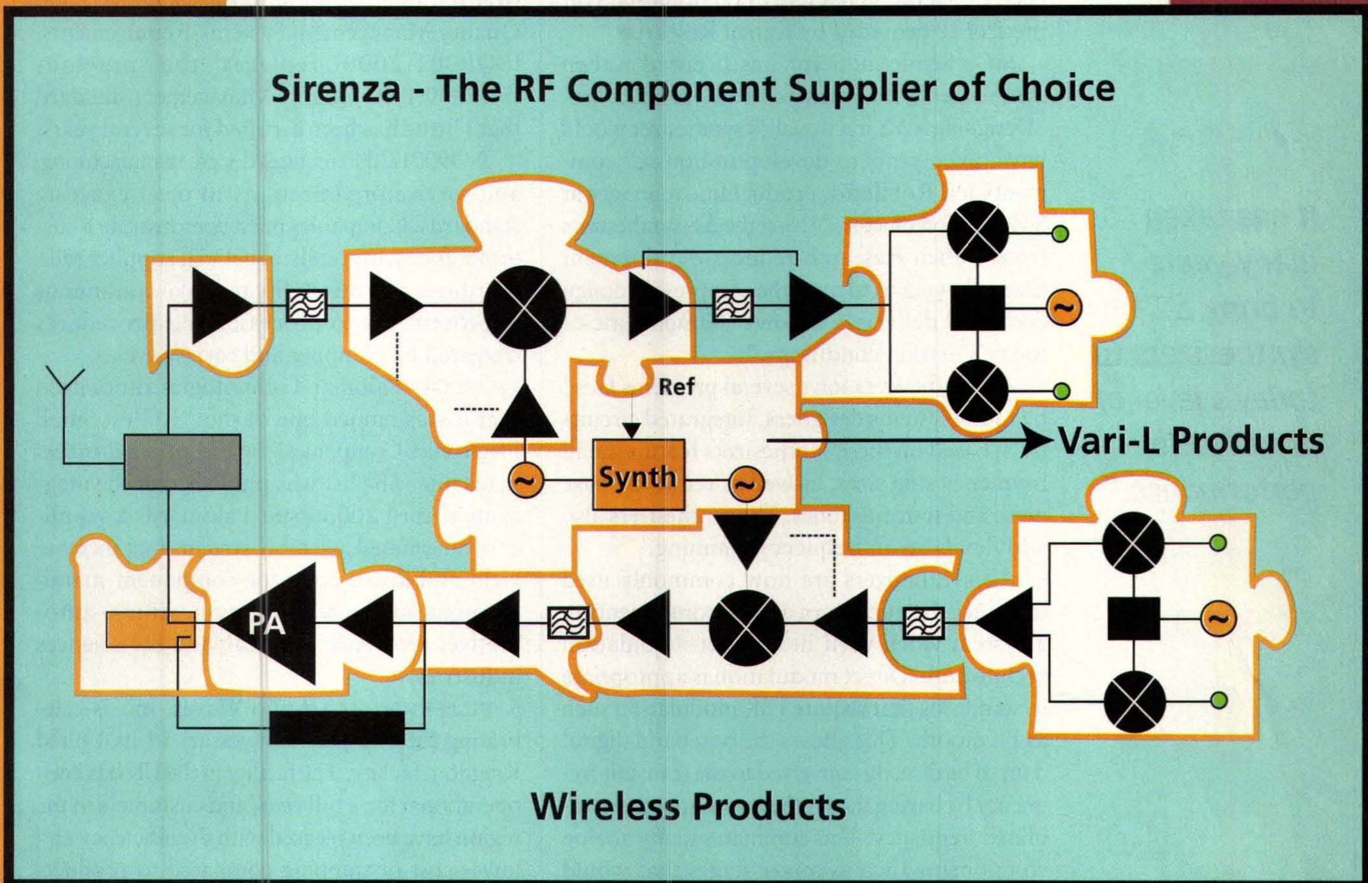

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SIRENZA MICRODEVICES

SiGe Semiconductor Licenses Fractional-N Synthesizer IP

OTTAWA, ONTARIO, CANADA—Kaben Research, Inc., a developer of mixed-signal, intellectual-property (IP) blocks for wireless manufacturers, announced that SiGe Semiconductor has licensed Delta-Sigma (ΔΣ) Fractional-N Synthesizer IP provided by Kaben Research.

SiGe Semiconductor has licensed Kaben Synthesizer IP for use in its GPS IC product line. "Designing a ΔΣ fractional-N synthesizer would have taken years to develop in-house," comments Jeff Robillard, product line manager at SiGe Semiconductor. "Using the ΔΣ synthesizers from Kaben Research reduces development time, allowing us to meet the compressed design cycle and delivery windows characteristic of today's market conditions."

"It has taken many years to bring ΔΣ synthesizers to today's level of predictable performance."

ΔΣ synthesizers solve several problems faced by radio-systems designers. Integrated circuits (ICs) based on these synthesizers feature small frequency step sizes, as well as reduced phase noise and spurious tones. The synthesizers also add flexibility in frequency planning.

ΔΣ synthesizers are now commonly used to reduce the number of analog components in a system when used in a direct-modulation architecture. Direct modulation is appropriate in standards that require FSK modulation such as Bluetooth. This allows the baseband digital data to be directly converted to the transmit frequency by having the synthesizer output the modulated frequency. This eliminates many analog components such as mixer stages that would normally be used to upconvert or modulate the transmitted signal.

Tom Riley, chief technology officer at Kaben Research, states, "It has taken many years to bring ΔΣ synthesizers to today's level of predictable performance."

"Kaben's ΔΣ Synthesizer IP block enables SoC manufacturers to achieve the desired system performance in a reduced time frame," comments Seste Dell'Aera, Kaben's vice president of marketing. "This mature technology can be licensed for integration into wireless systems such as Bluetooth, cable modems, and WLAN 802.11a/b/g."

Kudos

CHELMSFORD, MA—Hittite Microwave Corp., a designer and manufacturer of RF ICs, MMICs, MCMs, and MIC assemblies for RF/microwave applications, has successfully completed a transition of their Quality Management System culminating in a recertification audit to the requirements of ISO9001-2000.

TÜV America, Inc. has recommended Hittite to the Registration Accreditation Body (RAB) for certification to the ISO9001-2000 Quality Management Systems-Requirements. ISO9001-2000 replaces the previous ISO9000:1994 Quality Management standard that Hittite has been certified for several years.

ISO9001-2000 requires design, manufacturing, and service organizations to meet exacting standards. Companies must demonstrate a customer focus, mutually beneficial supplier relationships, and the ability to make continuous improvements to processes and procedures triggered by planning and review cycles.

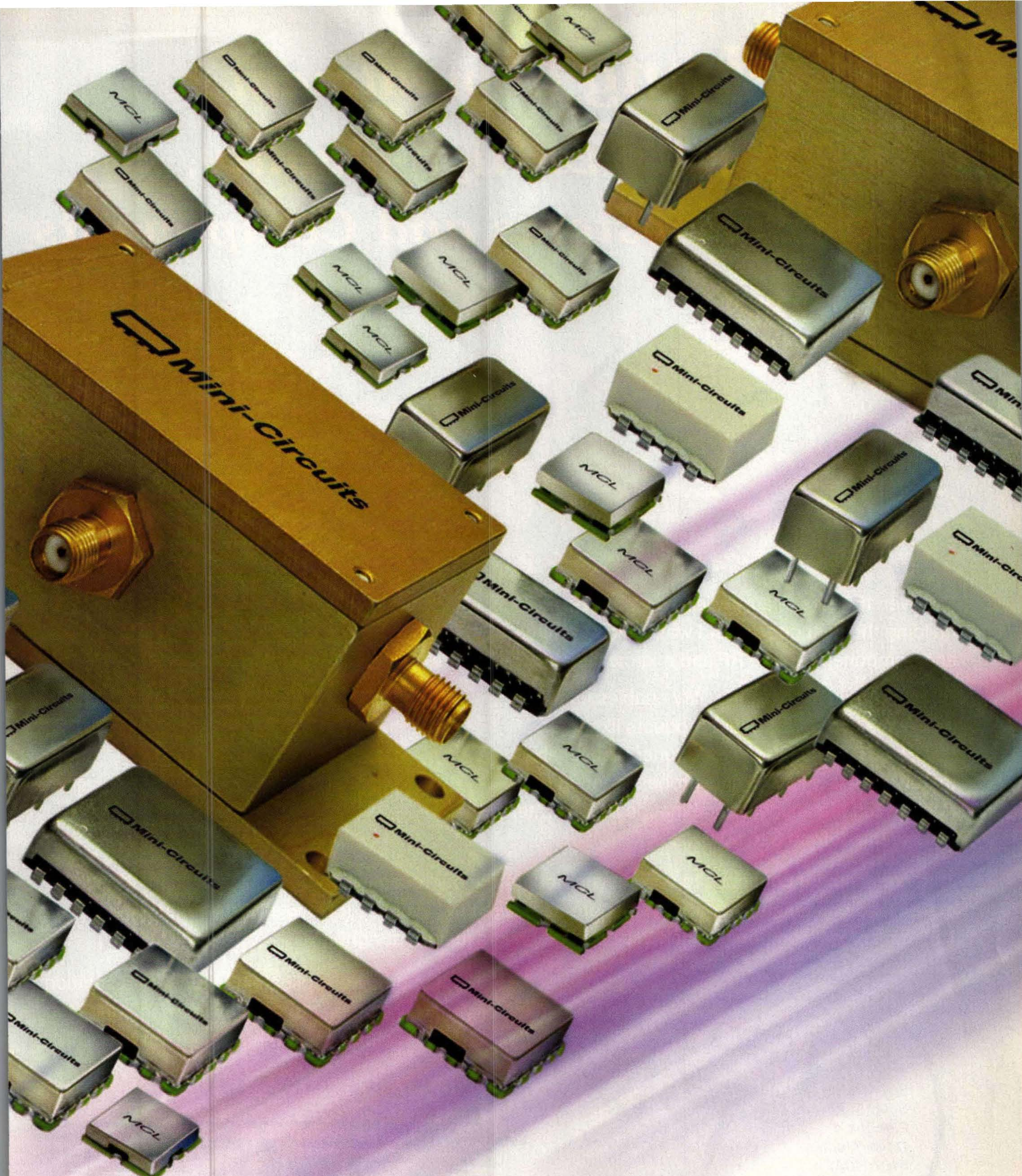
VISTA, CA—Palomar Technologies announced that it was named one of the "30 Best Small Electronics Companies" by *Electronic Business* magazine. The list was published in the magazine's April 2003 issue. Palomar is a supplier of automated assembly systems that increase yield and lower costs for component manufacturers in the telecommunications, automotive, aerospace, medical, and life-sciences industries.

N. BILLERICA, MA—Radio Waves, Inc. is celebrating the one-year anniversary of its United Kingdom facility. The facility in the UK has been operational for a full year, and customers in the region have been pleased with the efficiency and lower cost of shipping compared to products manufactured in the Americas. Radio Waves supports customers in Europe, Africa, and the Middle East from its UK manufacturing facility.

CEDAR RAPIDS, IA—Rockwell Collins' high-speed SATCOM system has received Federal Aviation Administration (FAA) Supplemental Type Certification (STC) on the Challenger 600, 601, and 604. The installation and STC was completed by Bombadier Aerospace.

The Collins HST-900 enables enhanced passenger connectivity, including access to e-mail and the Internet while in flight. Designed as a companion to the Collins SAT-906 satellite-communications system, the HST-900 provides high-speed connectivity using Inmarsat's Swift64 service.

Once installed, the HST-900 can be upgraded for new generations of Inmarsat high-speed data services without affecting the SAT-906 functionality. MRF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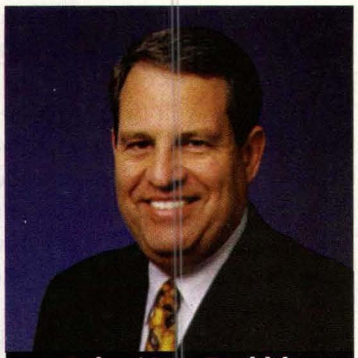
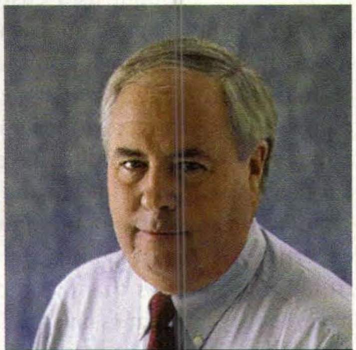


Robert Van Buskirk



Chuck Bland

An Interview with Sirenza's Robert Van Buskirk and Chuck Bland

Sirenza Microdevices (Sunnyvale, CA) acquired the assets of the Vari-L Co. (Denver, CO) on May 5, bringing together companies with different product lines but similar cultures. Integration of the two companies offers traditional manufacturing capability to Sirenza (a fabless company), along with 50 years of experience in VCOs, PLLs, and other frequency generation devices, and a presence in the defense market. Vari-L benefits from Sirenza's breadth of design and semiconductor expertise, greater capitalization, and similar interests in the infrastructure market. **Robert Van Buskirk**, CEO of Sirenza, and **Chuck Bland**, formerly CEO of Vari-L and now COO of Sirenza, offer two points of view on the new organization.

MRF: *Tell us a little about Sirenza's history.*

Van Buskirk: The company was founded by John Ocampo and his wife, Susan, who are still the company's largest shareholders. John is chairman of the board and Susan is treasurer. Their vision was to develop a broad range of new products featuring advanced technologies, but since they were self-funded they did not have the capital required for manufacturing. However, the fabless business model gave them a practical way to bring many advanced technologies to the market. The company actually started out as a semiconductor packaging supplier called Matrix Microassemblies. John and Susan took products originally intended for defense applications and applied commercial packaging and test processes for commercial applications. With their defense heritage, these products had high performance and were well suited to wireless-infrastructure applications, which is how the company moved into that area. The company ultimately changed its name to Stanford Microdevices, and to Sirenza Microdevices in January 2001.

MRF: *What attracted you to the company?*

Van Buskirk: I met John when I was at TRW where I was responsible for its commercial GaAs business. Stanford Microdevcices was one of our foundry customers. I knew the pros and cons of being a fabless company, and I had become a proponent of the fabless business model. I joined the company because I had a keen interest in further developing that model.

MRF: *What led Vari-L to seek an acquisition partner?*

Bland: We knew for several years that it would be necessary for Vari-L to diversify its product line to remain competitive in some important market segments. When your primary customers are manufacturers of base-station equipment, the size of your company and the breadth of its solutions definitely matter. These large companies are intensely focused on reducing cost, and they will retain only those suppliers that can help them achieve it. They demand a wide range of design solutions and the ability to deliver functional blocks, not just a single-function component. To prosper in this environment, we needed engineering talent that spans the entire transmit and receive chain. Sirenza's strength in amplifiers and semiconductors seemed to be very complementary to Vari-L's expertise in VCOs and PLLs. We felt that together we could provide the multifunction modules that base-station manufacturers are asking for, as well as more versatile design services.

MRF: *Apparently, several suitors were pursuing Vari-L. Why did Vari-L ultimately choose Sirenza?*

Bland: Seven companies were interested in Vari-L. We chose Sirenza because we saw a fit between our strengths and theirs, and because Sirenza is well capitalized, so it has staying power for the long term. Both companies are also focused on serving the infrastructure marketplace, and have similar goals.

Van Buskirk: At Sirenza, we knew also that size and versatility were becoming crucial. Customers told us it would be advantageous for us to broaden our products and technology. Vari-L looked like a partner that could make this happen. We had lots of versatility in semiconductors, but Vari-L would give us oscillator, synthesizer, mixer, and passive component expertise. Having a global footprint is also important, and large portions of Sirenza's sales are to countries other than the US, which is true also for Vari-L. Now when we go to these companies we'll be able to offer a much more complete solution.

MRF: *Can you give us an example of the functional integration you spoke about earlier?*

Bland: In the past, our customers would put our VCO on a circuit board and add components around it to create a PLL. Of course, when you put bare components down, your yield suffers. When they get the complete PLL from us, they're assured that it meets their specifications. They don't have to worry about variations in individual components because we have already absorbed them in our manufacturing process, so yield for the customer is much higher. Now that we are part of Sirenza, we can take this approach with a far greater array of multifunction components.

Van Buskirk: Taking this further, there are two basic ways Sirenza and Vari-L together can offer customers an appealing solution: integration and bundling of components. By integration, I mean that we can take Sirenza's RF IC components and integrate them with Vari-L signal source components to create a multifunctional module. Bundling is essentially giving the customer a single course for Sirenza and Vari-L products, which increases volume, and allows us to reduce prices.

MRF: *What were some of the other advantages Sirenza felt it would gain by acquiring Vari-L?*

Van Buskirk: Well first, we were very impressed with Vari-L's responsiveness to customers. Vari-L's is truly adept at delivering custom products in a remarkably short time, usually in two weeks from the time they receive the customer specification. About 80 percent of Vari-L's sales are custom products designed to meet specific customer specifications. Vari-L brought us a customer base that complemented our own, and if you interleave Vari-L commercial customers with ours, they fit. For example, Vari-L has a long relationship with Nokia and Motorola and we have similar relationships with Lucent and Ericsson. Vari-L also has manufacturing expertise in low-cost hybrids and multifunction modules that we did not have, so they brought us an established manufacturing core competence and a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MRF: *Vari-L has a presence in the defense market, which Sirenza did not have. Was this an important consideration as well?*

Van Buskirk: It was extremely important to us. Vari-L has considerable experience in the defense market, and long-term relationships with defense contractors. About 20 percent of Vari-L's sales are in the defense area. This is an entirely new market opportunity for Sirenza, and Vari-L's relationships should allow us to introduce Sirenza's products into the defense industry.

MRF: *What organizational changes are taking place now that the acquisition is complete?*

Bland: Vari-L will be rapidly integrated into Sirenza, and the Vari-L name will disappear over time. When we announced completion of the acquisition, we also announced that Sirenza's corporate headquarters, as well as its manufacturing activities, will be consolidated in the Denver area. Sirenza has a small semiconductor test and packaging operation in Sunnyvale, and manufacturing facilities in Tempe, AZ, both of which will move to the new location. We have leased two 35,000-sq.-ft. facilities, one for manufacturing and one for administration at the Interlocken Advanced Technology Environment in Broomfield, CO. The facilities in Tempe and Sunnyvale will continue as design centers, along with others in Dallas and Torrance, and we closed our facilities in Ottawa on April 28 as a cost-cutting effort. Dallas and Denver will share support for the Ottawa product lines.

MRF: *How will the new company be structured?*

Van Buskirk: The company now has two divisions, the amplifier-products division, which contains the core Sirenza capabilities, and the signal-source division, which contains the core Vari-L competency with the addition of some of Sirenza's signal-processing capabilities.

MRF: *How is this affecting your work force?*

Van Buskirk: Before we acquired Vari-L, Sirenza had about 135 employees and Vari-L about 205. When our move is complete, there will be about 260 employees. We did provide financial support for Sirenza employees in a potential relocation to Colorado.

MRF: *What was the appeal of Denver?*

Van Buskirk: Denver is an excellent area from both personal and financial perspectives. It costs less to operate and live there than in California, and Inter-

locken is a beautiful 963-acre hi-tech campus in an area that is rapidly becoming Denver's technology corridor. The campus is surrounded by nice communities, a golf course, bike and hiking trails, and a new 1.2-million-sq.-ft. mall near the entrance to the park. It's a growing community that has placed strong emphasis on the environment. Vari-L has also developed a more highly-developed information technology infrastructure than we have at Sirenza, and it is easier to relocate Vari-L's manufacturing locally.

MRF: *Can you tell us about any new products you will soon introduce that utilize the capabilities of both companies?*
Bland: We're working on a commercial mixer line that lets us combine Vari-L's manufacturing and process engineering expertise with Sirenza's design capabilities. These mixers should be available 60 days after we consolidate. We will also expand the PLL line, which has been focused on the base-station infrastructure market, with models for other commercial segments.

MRF: *Sirenza has recently entered the optical components market with transimpedance amplifiers (TIAs). Considering this market is currently even more depressed than the wireless market, why did you choose to enter it?*
Van Buskirk: We feel that this market has excellent potential in the long term. When this market turns up, which I believe it will, there will be few component suppliers left that can supply high-performance amplifiers. Sirenza will be well positioned to capitalize on this upturn. It is important to remember that we are not interested in photonics, clock recovery circuits, or other optical components. We will make components such as TIAs, limiting amplifiers, and modulator driver amplifiers, all of which are well centered in our core of high-performance amplifiers. And we are learning a lot about higher-frequency techniques that we can spin off to non-fiber applications.

MRF: *How about millimeter-wave applications?*
Van Buskirk: We made the right move by not putting much investment into applications like LMDS, which has essentially disappeared, at least for now. There is some cellular backhaul activity, ultrawideband at 60 GHz, radar at 77 GHz, and some other applications. However, we are interested in all applications that can benefit from high-performance very-broadband amplifiers in the 20-to-40-GHz range. In particular, more than 20 GHz with SiGe and more than 20 GHz with InP.

MRF: *Is there any chance Sirenza will move up the "food chain" into manufacturing subassemblies?*
Van Buskirk: No, we're very comfortable being a component supplier. People are asking us to integrate more and more functions into multicomponent modules, and that is appealing to us, but subassemblies are not. It's always tempting to start gazing upward in the value chain because the top line moves up fast. However, margin can slip away just as quickly. Can we grow a billion-dollar component business in the next few years? Probably not, but we can build a very profitable smaller one. Sirenza has had five consecutive quarters of 50 percent or higher margins.

MRF: *What is your view of the current market conditions?*
Bland: The microwave-components market is awash with oversupply, and there are just too many companies selling similar products. Competition is fierce and prices are dropping. The price of VCOs is half of what it was three years ago, and we're still working down the price curve. I think you'll see a shakeout in the industry, as the big contractors retain only suppliers that deliver the most versatile design solutions, greatest ability to integrate functions, fastest delivery, best performance, and of course, the lowest cost. We see signs of this already, where once we had several viable competitors for a program, today there is often only one.
Van Buskirk: The large wireless infrastructure manufacturers have under-

taken major cost cutting, and I think the process of getting lean and mean is mostly behind them now. Their next challenge is to battle it out to see who will survive. We see some stability returning, and although our order patterns are still close in, our customers are beginning to talk several quarters out, which simply has not been the case over the last two years. We see more stability in other areas too, and some of the applications that simply vanished are coming back. Our book-to-bill has been above 1 in the last few quarters, and firm orders entering a new quarter are creeping upward.

MRF: *How about the wireless LAN market, which seems to be a frenzy of activity?*

Van Buskirk: Frenzy is definitely the key word there. We looked at 2.4-GHz power amplifiers, and in the two quarters it took to analyze the market, the price went down 30 to 40 percent, with many suppliers trying to get into the same socket. We have some catalog product SiGe amplifiers used in WLAN applications, but we are not putting a lot of R&D into this market.

MRF: *Sirenza proclaims itself as focused on infrastructure. However, based on your comments, is that selling the company a bit short?*

Van Buskirk: The impression is that we are an infrastructure company. But if you look at our design wins over the last year, about half are for wireless infrastructure and half are in other RF applications. A good example is X-10, the company whose pop-up ads for wireless video equipment splash across your screen. We've been selling to them for several years. They're coming out with a 5.8-GHz version with better resolution, and we'll be in that too. Sirenza components are also in set-top boxes, vehicle monitoring/tracking systems, RFID systems, and WLL repeaters. With Vari-L's hi-rel capability we'll be in the defense market too. We firmly believe in diversity, and it's helped us withstand the lean times and prepare ourselves for the prosperous ones.

MRF: *How is the integration of the two companies progressing?*

Bland: In the acquisitions I have participated in, we always identified a list of expected synergies, both operational and financial, between the two companies, and once the integration began we often discovered that we had overestimated. But in this case, we have found greater synergy between the two, which was a pleasant surprise. It is critical after an acquisition that you create an environment that fosters a shared vision and this is well underway at Sirenza. MRF

Software Helps Calibrate Vector Network Analyzers

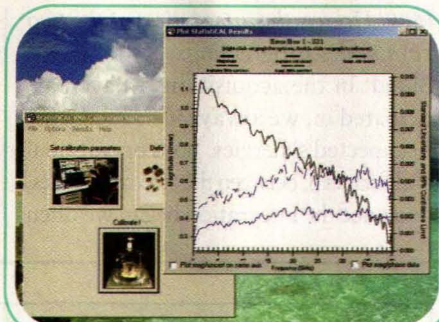
FREE SOFTWARE CAN improve the accuracy of vector-network-analyzer (VNA) calibrations. The software, which is based on an algorithm developed at the United States National Institute of Standards and Technology (NIST) and the Physikalisch-Technische Bundesanstalt (PTB) of Germany, accommodates almost all coaxial and on-wafer calibration standards. Using statistical analysis, uncertainties in a calibration solution are represented by a covariance matrix that relates errors to both the VNA calibration and the measurements of the device under test (DUT). The software's algorithm determines coverage factors based on the different numbers of degrees of freedom associated with various parts of the solution. The software can be downloaded from the NIST website.

NIST Boulder, Mail Stop 346.16, 325 Broadway, Boulder, CO 80305-3328; (303) 497-5507, FAX: (303) 497-3246, Internet: www.boulder.nist.gov/dylan/.

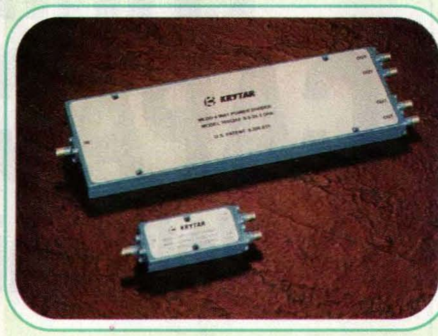
Two-Way Divider Spans 0.5 To 26.5 GHz

SUITABLE FOR INSTRUMENTATION and other broadband applications, the model 6005265 two-way power divider features a frequency range of 0.5 to 26.5 GHz. The insertion loss is only 2.5 dB to 18 GHz and only 1.9 dB to 26.5 GHz, while the VSWR is only 1.45:1 to 18 GHz and 1.60:1 to 26.5 GHz. The amplitude tracking is 0.3 dB from 0.5 to 18 GHz ad 0.5 dB from 18 to 26.5 GHz. The phase tracking is 6 deg. from 0.5 to 18 GHz and 10 deg. from 18 to 26.5 GHz. The company offers a variety of other two-way power-divider models in various frequency bands with tighter amplitude and phase tracking as required.

Krytar, 1292 Anvilwood Court, Sunnyvale, CA 94089; (408) 734-5999, FAX: (408) 734-3017, e-mail: sales@krytar.com, Internet: www.krytar.com.

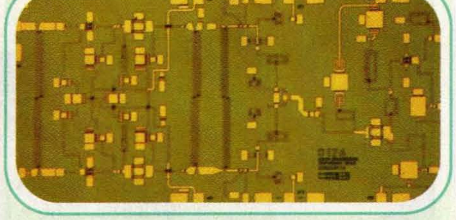


NIST SOFTWARE



KRYTAR 6005265 POWER DIVIDER

SPACEK LABS' MODEL P60-1B RECEIVER



MIMIX BROADBAND'S 22REC0174 RECEIVER

Receiver Eases V-Band LNA Measurements

NOISE-FIGURE TESTING of V-band low-noise amplifiers (LNAs) is simplified with the model P60-1B receiver. The unit operates with a 10-GHz bandwidth in V-band, with an option for full V-band coverage (50 to 75 GHz). Local-oscillator (LO) signals for downconversion of RF test signals to intermediate frequencies (IFs) are derived by means of a ×3 multiplier, with an option for a ×4 multiplier for use with lower-frequency LO sources. The receiver has an IF range of 10 to 500 MHz with typical RF-to-IF gain of 25 dB. The double-sideband noise figure, including the loss of a Faraday isolator, is no worse than 8 dB and typically 6.5 dB. Excluding the isolator, the noise figure is typically 5 dB.

Spacek Labs, 212 East Gutierrez St., Santa Barbara, CA 93101; (805) 564-4404, FAX: (805) 966-3249, e-mail: spacek@silcom.com, Internet: www.spaceklabs.com.

Subharmonic Receiver Ranges 18 To 25 GHz

MILLIMETER-WAVE point-to-point radio designers can take advantage of the new model 22REC0174, an integrated-circuit (IC) subharmonically pumped receiver. Designed for an RF range of 18 to 25 GHz, the receiver IC integrates a two-stage balanced LNA, an image-reject subarmonic anti-parallel diode mixer, and an LO buffer amplifier. The GaAs IC achieves a noise figure of 2.5 dB with 15-dB image rejection across the full 7-GHz band. The receiver is designed to operate with LO of 10 GHz at a drive level of only +2 dBm. The device replaces three or four single-function ICs and a printed bandpass filter, and is suitable for use in the 24-GHz industrial-scientific-medical (ISM) band.

Mimix Broadband, Inc., 10795 Rockley Rd., Houston, TX 77099; (281) 988-4600, FAX: (281) 988-4615, Internet: www.mimixbroadband.com.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UWB Deployment Grows Rapidly

A REPORT FROM ALLIED Business Intelligence, Inc. (ABI), "Ultra Wideband (UWB) Wireless—An Evaluation of Technology Prospects and Potential Market Applications," examines if UWB will be the next generation in wireless communications, for diverse applications including wireless LANs and radar. The total global shipments for UWB-enabled electronics and chip sets could reach 45.1 million units by 2007, with resulting revenues of $1.39 billion by the end of that year.

The lack of a definable standard is the single biggest shortfall to the development of a sustainable UWB market. In addition, a battle between entrenched wireless carriers and new supporters of UWB technology has unfolded recently, possibly hindering the market potential for UWB. Joining the wireless carriers are GPS and avionics equipment makers, among others, who fear UWB making unwanted inroads into their territory. Collectively, these companies have deep pockets and considerable power to lobby against UWB technology.

The rosiest prospect for widescale deployment of UWB exists with the consumer-electronics (CE) industry. The concept of sending data, video, and audio content wirelessly seems to be the near-term future of networking information and distributed computing. "Wired networking is cost prohibitive when compared to that of wireless solutions," explains Vamsi Sistla, author of the ABI report, "Entertainment Networking ICs," and an ABI senior analyst. "Wireless' projected success is derived from the rapid drop in silicon prices, in tandem with consumers' reception to the inherent benefits of mobility and flexibility," continues Sistla.

Already low and decreasing costs of WiFi implementation, gear, and deployment are some of the main drivers of WiFi technologies. According to ABI forecasts, UWB chip-set shipment growth for video and host device applications will more than double in the years 2005 and 2006, from 1.5 million UWB IC shipments in the year 2004 to 3.4 million UWB IC shipments in the year 2005, and to 7.7 million UWB IC shipments in the year 2007. MRF

CONTRACTS

Motorola—Announced that PT. Telkom, Indonesia's largest telecommunications operator, has selected a Motorola cdma2000 1X system to bring 3G wireless services to the ten provinces of Sumatra. Sumatra is one of the largest islands and one of the fastest-growing areas in Indonesia.

The contract win is the 15th announced 3G contract for Motorola worldwide, and the seventh in the Asia-Pacific region. The estimated contract value for the initial phase of the cdma2000 1X network rollout is nearly $30 million, with allowances for additional capacity should PT. Telkom decide to expand the network. The network was commercially deployed in April, and runs on the 800-MHz band.

REMEC, Inc.—Announced that Counties Power Ltd. of New Zealand has selected REMEC's ExcelAir® 70 platform to be used in their networks to provide high-speed Internet access and telephony services in the Pukekohe through Papakura areas of New Zealand. Counties Power plans to provide broadband services to over 3000 customers during Phase 1 of Counties Power's "Wired Country" project. Integration testing for the wireless equipment and the fiber-optic backbone equipment has already been completed.

MCI—Have announced that Munich, Germany-based Wacker Chemie GmbH, a global provider of chemicals and semiconductor operations, has selected MCI as its primary global communications provider. Under the terms of the multiyear, multimillion-dollar agreement, MCI will design, build, and fully manage a new global VPN network for Wacker to carry data and voice traffic among 70 facilities located on four continents.

FRESH STARTS

Hittite Microwave Corp.—Appointed Saguaro Technical Sales, Inc. (STSI) as its sales-representative firm to serve customers in Arizona and New Mexico. STSI was established in 1994 and is headquartered in Scottsdale, AZ.

Kyocera America, Inc.—Plans to move its Beaverton, OR Low Temperature Co-fired Ceramic (LTCC) manufacturing operations into its 288,000-sq.-ft. main manufacturing facility in San Diego, CA.

The move is expected to be complete by August 31, 2003, when the lease for the current facility in Beaverton expires. A number of the facility's 45 employees have been offered relocation packages, while others will continue to maintain a small product-technology and sales center in the Beaverton, OR area.

Rogers Corp.—Announced the new trade name for its family of Liquid Crystalline Polymer (LCP) circuit materials. Previously named ZYVEX™ laminates, the product line is now being referenced as Rogers R/flex® 3600 Liquid Crystalline Polymer laminate materials.

The R/flex name is an already established Rogers' trade name for its other laminate materials. The numeric that follows the names will distinguish each product line from the group.

Palomar Technologies—Has entered into agreements with several companies to sell Palomar's assembly automation products and process-development services in Asia.

Autron will offer Palomar's equipment and process solutions to its optoelectronics customer base in Malaysia, Thailand, Taiwan, and China. Palomar's representatives in China also include Dymek Asia and ETSC Tech. Globaltech Corp. will represent Palomar in the Philippines, with Qualmax, Inc. in South Korea, and Marubun Corp. in Japan.

Johnstech International Corp. and Agilent Technologies, Inc.—Announced that Johnstech has agreed to purchase the Agilent YieldPro and YieldPro Array contactor technologies and products.

The agreement includes a license to use existing patents. It also includes design and manufacturing methodologies and an installed customer base. Johnstech is expected to become the sole provider worldwide of the YieldPro and YieldPro Array products and plans to continue Agilent's work to further develop and enhance these technologies. Agilent released the YieldPro in 1995 and YieldPro Array in 2000 as the "final millimeter" for the Agilent SoC tester platforms.

QUALCOMM, Inc.—Announced that its Board of Directors has declared a quarterly dividend of $0.05 per common share, payable on June 27, 2003 to stockholders of record at the close of business on May 30, 2003.

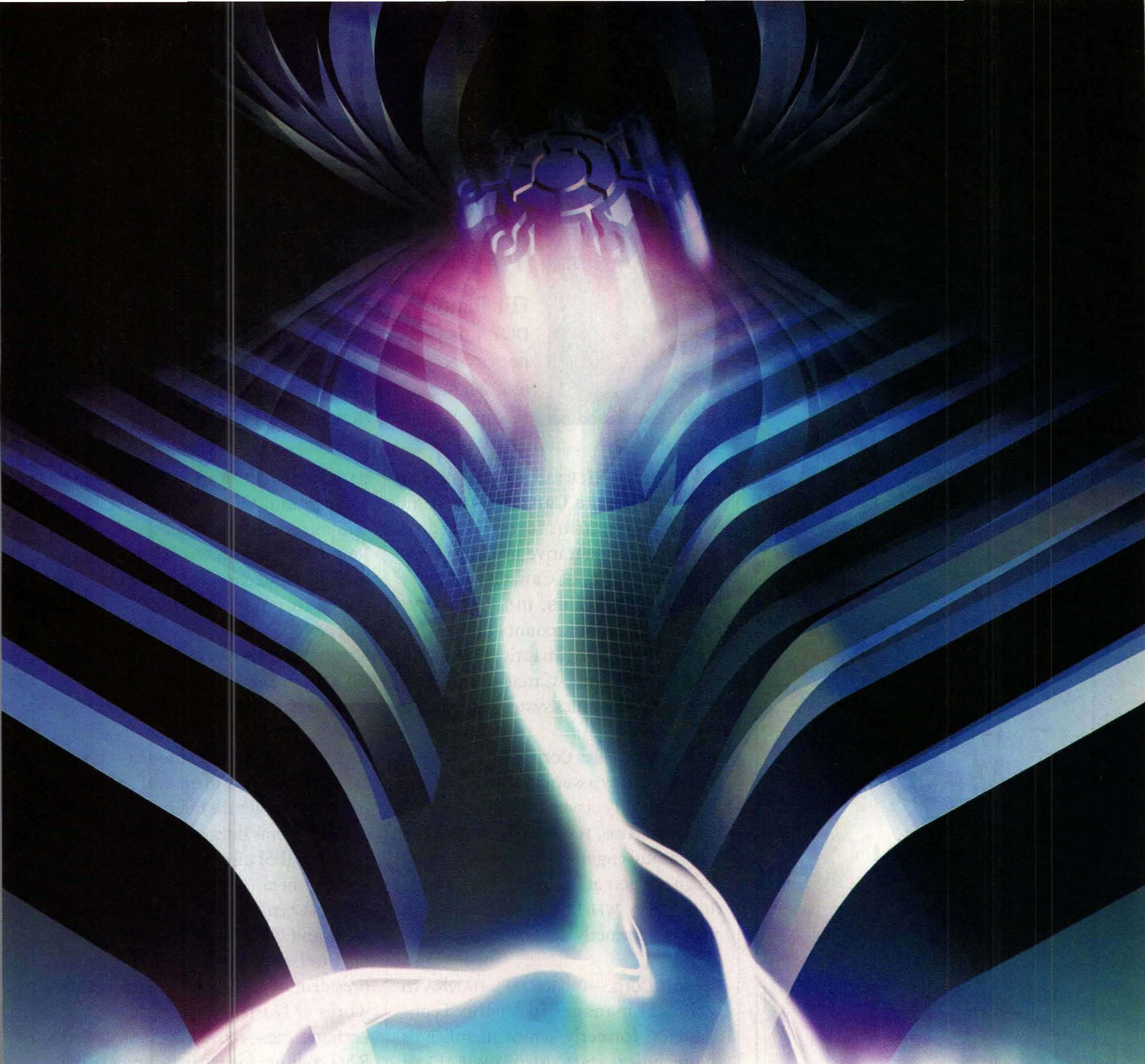
Phihong—Has opened a new design center in Ronkonkoma, NY to house the company's expanded research-and-design (R&D) team specializing in the development of power products with ratings of up to 2000 W.

KDF—Announced that Honeywell International has placed a follow-on order for a 943NT in-line sputtering system. This follow-on order provides production-proven validation for KDF's 943NT system in aerospace applications.

Honeywell installed its first 943NT system at its Minneapolis facility in June 2001. The current order for Honeywell's second 943NT system was installed at the same facility in January 2003 and will be used to produce ring laser gyroscopes for Honeywell's aerospace business.

Tanner EDA—Has announced the formation of its wholly owned Japanese subsidiary, Tanner Research Japan K.K. (Tanner Japan). In conjunction with this expansion, Tanner EDA has announced the availability of multi-language support for its flagship product, L-Edit Pro, including native Japanese-language menus.

Headquartered in Tokyo, Tanner Japan will spearhead sales and technical support of Tanner EDA products throughout the region. These include the company's L-Edit Pro layout and verification tools, as well as its T-Spice Pro design entry and simulation software. Tanner Japan will also manage local corporate marketing and business-development efforts. MRF




MENDOZA

ITT Cannon Names Mendoza To Director Of HR Spot

ITT Industries, Cannon has named BRUCE R. MENDOZA as director of human resources for its connector operations in Santa Ana, CA and Nogales, Mexico. Most recently, he served as director of human resources for Hewlett Packard's VeriFone division.

Entela, Inc.—PETER SANSONE to account manager for the Canadian office in Toronto, Ontario; formerly senior account representative at Underwriters Laboratories of Canada (UL).

EMS Technologies, Inc.—STEPHEN NEWELL to senior account manager for the SATCOM Aeronautical Group in Ottawa, Ontario, Canada; formerly manager of avionics systems at AIRIA, Inc.

Sullins Electronics Corp.—ANTONY TRUPANS to quality assurance manager; formerly quality assurance manager at Kyocera. Also, HALINA SZCZESNIAK to mechanical engineer; formerly machine design engineer at Autosplice, Inc. In addition, JOHN WHITE to plastics/design engineer; formerly designer with MIOX Corp.

Sarnoff Corp.—DR. KEITH J. HANNA to technical manager in Vision Technologies; formerly senior member of the technical staff. Also, DR. RAKESH "TEDDY" KUMAR to technical director in Vision Technologies; formerly technical manager.

The Aerospace Industries Association—MICHAEL ROMANOWSKI to assistant vice president for Civil Aviation; formerly employed with Sikorsky Aircraft and Pratt and Whitney. Also, REMY NATHAN to director of international affairs; formerly employed at the US-ASEAN Business Council.

Qwest Communications International, Inc.—JOHN W. RICHARDSON to controller and senior vice president of finance; formerly vice president of finance for the North American Tire business unit at the Goodyear Tire & Rubber Co.

California Micro Devices—R. GREGORY (GREG) MILLER to vice president of finance and CFO; formerly CFO at Summit Microelectronics.

Raytheon Co.—BIGGS C. PORTER to vice president and corporate controller; formerly corporate controller for TXU Corp.

Maury Microwave Corp.—RICK STURDIVANT to the engineering team; formerly senior scientist at Multilink Technology Corp.

BAE SYSTEMS North America—JEFFREY COOK to vice president and chief technology officer for the Information & Electronic Systems Integration (IESI) Sector; formerly IESI director for research and development (R&D).

Proxim Corp.—FRANK PLASTINA to president and CEO as well as membership on the board of directors; formerly president of Metro and Enterprise Networks at Nortel Networks Corp.

Enthone, Inc.—DR. ANDREAS MOEBIUS to R&D fellow; formerly technical director in Europe for the Enthone R&D organization.


MOEBIUS


SULLIVAN

StratEdge—DANIEL L. SULLIVAN to eastern region sales manager; formerly space products manager at Alpha Industries.

ADC—DILIP SINGH to president of the Software Systems Business Unit; formerly entrepreneur-in-residence at M/C Venture Partners. MRF

▸SHORT COURSES

Oxford Design Week
June 29-July 4 (Oxford, England)
St. Anne's College
Internet: www.rttonline.com

RF Wireless Principles and Practice: Wireless Systems, Radio Receivers, Frequency Synthesizers, and Power Amplifiers
July 14-19 (Atlanta, GA)
Georgia Tech campus
For further information, contact:
Sean Travers
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(404) 385-3541, FAX: (404) 894-7398

Indoor Networks: Principles & Practice of In-Building Wireless Engineering
August 7-8 (Miami, FL)
September 11-12 (San Francisco, CA)
For further information, contact:
Dr. Eric Reifsnider
(540) 818-2281
e-mail: training@wirelessvalley.com
Internet: www.wirelessvalley.com/Services/Training.asp

Antenna Measurement & Techniques Association (AMTA) 2003 Short Course: Selected Topics from Veteran AMTA Speakers
October 19-24 (Irvine, CA)
Hyatt Regency Hotel
For further information, contact:
John Demas
e-mail: jdemas@nearfield.com
Internet: www.amta2003.com

▸MEETINGS

802.11 Planet Spring 2003 Conference & Expo
June 25-27 (Boston, MA)
World Trade Center
For more information, visit:
http://destinationsite.com/c?c=831691.156936.0.738.0
For information on exhibiting or sponsorship opportunities, contact:
Tim Walsh
(203) 662-2838
e-mail: 80211@jupitermedia.com
For registration information, contact:
Lillian Potter
(203) 662-2857
e-mail: registration@jupitermedia.com

ISCC 2003: 8th IEEE International Symposium on Computers and Communications
June 30-July 3 (Antalya, Turkey)
e-mail: ahmed1@us.ibm.com
Internet: www.comsoc.org/iscc/2003

WCA 2003
July 8-11 (Washington, DC)
Washington, DC Convention Center
e-mail: Berndtson@aol.com
Internet: www.wcai.com/events.htm

INTERTECH 2003
July 28-August 1 (Vancouver, BC, Canada)
Hyatt Regency Vancouver
To register online, go to:
www.superabrasives.org
For more information, contact:
The Industrial Diamond Association
P.O. Box 29460
Columbus, OH 43229
(614) 797-2265, FAX: (614) 797-2264
e-mail: t-kane@insight.rr.com

2003 Prepaid Markets Expo
August 10-12 (New York, NY)
Marriot Marquis Hotel
For further information, contact:
(727) 399-2812
e-mail: expo@prepaid-telecom.com

Wescon North America
August 12-14 (San Francisco, CA)
Moscone Convention Center
Internet: www.wescon.com

2003 IEEE Symposium on Electromagnetic Compatibility
August 18-22 (Boston, MA)
Hynes Convention Center
Sponsored by the IEEE EMC Society
For further information, contact:
2003 IEEE EMC Symposium
c/o IEEE—Conference Management Services
445 Hoes Lane
Piscataway, NJ 08855
Internet: www.emc2003.org

PortablePower 2003
September 21-24 (San Francisco, CA)
Moscone Convention Center
For further information, contact:
Brooke Selby
IDG World Expo
(508) 424-4808
e-mail: brooke_selby@idg.com
Internet: www.idgworldexpo.com

25th Annual IEEE GaAs IC Symposium
November 9-12 (San Diego, CA)
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445 Hoes Lane
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Internet: www.gaasic.org

▸CALL FOR PAPERS

2003 IEEE International Electron Devices Meeting (IEDM)
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(301) 527-0900 ext. 103
Internet: www.ieee.org/conference/iedm

SiGe Process Yields Millimeter-Wave VCOs With Wide Tuning Ranges

MILLIMETER-WAVE VOLTAGE-CONTROLLED OSCILLATORS (VCOS) PATCH ANTENNAS (MPAs) are traditionally expensive, and have been a limitation in achieving affordable broadband millimeter-wave communications systems. Fortunately, Hao Li and Hans-Martin Rein of Ruhr-University Bochum (Bochum, Germany) have developed a series of low-phase-noise millimeter-wave VCOs with wide tuning ranges by using a production-ready SiGe bipolar process. The researchers report that the oscillation frequency can be changed from 36.0 to 46.9 GHz while still achieving phase noise of –107 to –110 dBc/Hz offset 1 MHz from the carrier. Employing the simple concept of a negative-resistance oscillator, the researchers fabricated sources with a 0.35-µm process from Infineon Technologies. Measurements of output power revealed about –4 dBm output power. See "Millimeter-Wave VCOs With Wide Running Range and Low Phase Noise, Fully Integrated in a SieGe Bipolar Production Technology," *IEEE Journal of Solid-State Circuits,* February 2003, Vol. 38, No. 2, February 2003, p. 184.

Modulating THz Radiation By Semiconductor Nanostructures

INCREASED DEMAND FOR BANDWIDTH may bring about the widespread use of millimeter-wave bands for communications. Should this be the case, research by T. Kleined-Ostmann and associates from the Intitut fur Hockfrequenztechnik (Braunschweig, Germany) offer powerful insights into modulation techniques for terahertz-frequency signals. Their approach involves the use of high-mobiliy electron gases confined within a semiconductor hetero-interface. See "Modulation of THz radiation by semiconductor nanostructures," *Microwave and Optical Technology Letters,* December 5, 2002, Vol. 35, No. 5, p. 343.

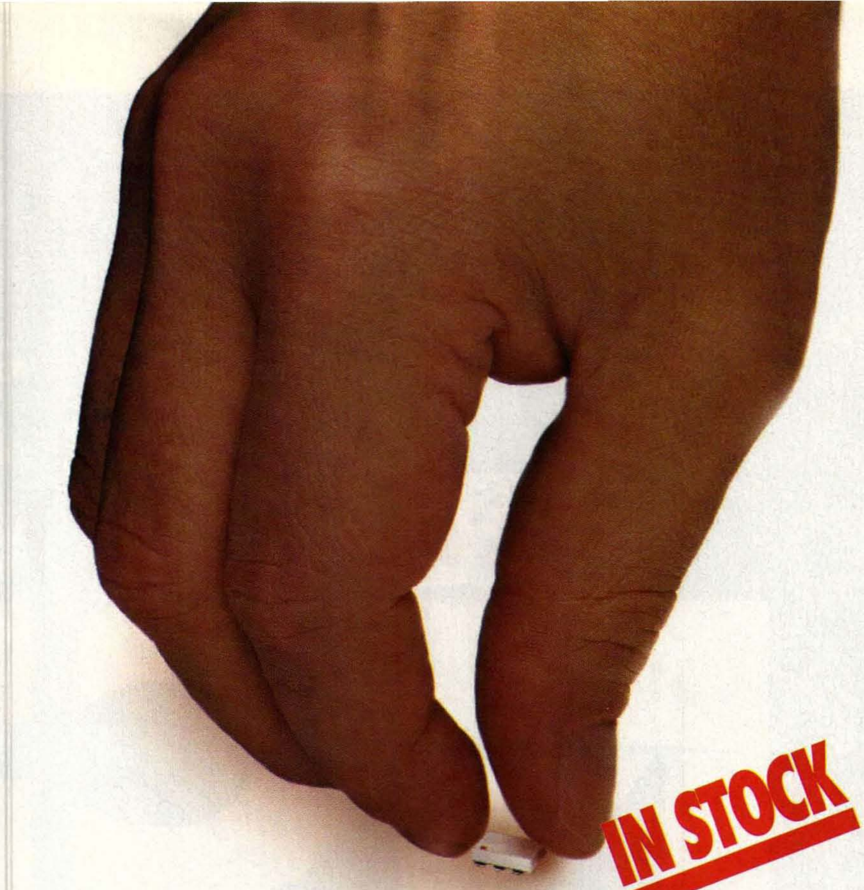
Internet Communicates Microwave Measurement Traceability

HIGHLY EFFICIENT AND COST-EFFECTIVE measurement services using vector network analyzers are now available on the Internet. Richard Dudley and Nick Ridler of the Centre for Electromagnetic and Time Metrology of the National Physics Laboratory (Teddington, Middlesex, England) report on the remote calibration and measurement using analyzers from two leading equipment suppliers has been accomplished via the Internet, for microwave frequencies from 45 MHz to 110 GHz.

The authors report how the NPL has combined remote monitoring, remote control, and national Measurement Institute (NMI) calibration techniques so that vector network analyzers can be calibrated and operated over the Internet. The service is based on the NPL's primary impedance measurement system (PIMS) for calibration of vector network analyzers. The system, which became fully operational in 2001, is used to directly measure the standards used by a client laboratory to calibrate their vector network analyzer. Measurement of these standards allows a direct assessment of the overall quality of the standards, and makes it possible to trace the uncertainty of measurements based upon these standards back to dimensional measurements. The NPL offers a full demonstration of the Internet-based calibration system by accessing www.internetcalibrations.com. See "Traceability via the Internet for Microwave Measurements Using Vector Network Analyzers," *The IEEE Transactions on Instrumentation and Measurement,* February 2003, Vol. 52, No. 1, p. 130.

Microstrip Array Antenna Aids Electronic Toll-Collection System

AUTOMATIC TOLL-COLLECTION SERVICES can speed travel across major thoroughfares. Working on behalf of the Electronic Toll Collection System (ETCS), researchers JoongHan Yoon and KyungSup Kwak from Inha University (Inchon, Korea) have developed a sequential-rotation microstrip array antenna for the 5.8-GHz Intelligent Transport System (ITS) band. The patch antenna, designed for roadside communications, employs right-hand circular polarization and achieves 22 dBi gain with a 20-percent 3-dB bandwidth. The antenna has a patch that measures 16.6 × 16.6 × 21.52 mm. The antenna, which was modeled by means of version 5.0 of the Ensemble software from Ansoft Corp. (Pittsburgh, PA), is impedance matched by means of a quarter-wave transformer. The use of paper absorber material helped reduce the sidelobe levels. See "Fabrication and Measurement of a Microstrip-Array Antenna for the Electronic Toll Collection System (ETCS)," *Microwave and Optical Technology Letters,* January 20, 2003, Vol. 36, No. 2, p. 77.



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ADE* TYPICAL SPECIFICATIONS:

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ADE-1L	+3	2-500	5.2	55	16	3	3.95
ADE-3L	+3	0.2-400	5.3	47	10	4	4.25
ADEX-10L	+4	10-1000	7.2	60	16	3	2.95
ADE-1	+7	0.5-500	5.0	55	15	4	1.99▲
ADE-1ASK	+7	2-600	5.3	50	16	3	3.95
ADE-2	+7	5-1000	6.67	47	20	3	1.99▲
ADE-2ASK	+7	1-1000	5.4	45	12	3	4.25
ADE-6	+7	0.05-250	4.6	40	10	5	4.95
ADEX-10	+7	10-1000	6.8	60	16	3	2.95
ADE-12	+7	50-1000	7.0	35	17	2	2.95
ADE-4	+7	200-1000	6.8	53	15	3	4.25
ADE-14	+7	800-1000	7.4	32	17	2	3.25
ADE-901	+7	800-1000	5.9	32	13	3	2.95
ADE-5	+7	5-1500	6.6	40	15	3	3.45
ADE-5X	+7	5-1500	6.2	33	8	3	2.95
ADE-13	+7	50-1600	8.1	40	11	2	3.10
ADE-11X	+7	10-2000	7.1	36	9	3	1.99▲
ADE-20	+7	1500-2000	5.4	31	14	3	4.95
ADE-18	+7	1700-2500	4.9	27	10	3	3.45
ADE-3GL	+7	2100-2600	6.0	34	17	2	4.95
ADE-3G	+7	2300-2700	5.6	36	13	3	3.45
ADE-28	+7	1500-2800	5.1	30	8	3	5.95
ADE-30	+7	200-3000	4.5	35	14	3	6.95
ADE-32	+7	2500-3200	5.4	29	15	3	6.95
ADE-35	+7	1600-3500	6.3	25	11	3	4.95
ADE-18W	+7	1750-3500	5.4	33	11	3	3.95
ADE-30W	+7	300-4000	6.8	35	12	3	8.95
ADE-1LH	+10	0.5-500	5.0	55	15	4	2.99
ADE-1LHW	+10	2-750	5.3	52	15	3	4.95
ADE-1MH	+13	2-500	5.2	50	17	3	5.95
ADE-1MHW	+13	0.5-600	5.2	53	17	4	6.45
ADE-10MH	+13	800-1000	7.0	34	26	4	6.95
ADE-12MH	+13	10-1200	6.3	45	22	3	6.45
ADE-25MH	+13	5-2500	6.9	34	18	3	6.95
ADE-35MH	+13	5-3500	6.9	33	18	3	9.95
ADE-42MH	+13	5-4200	7.5	29	17	3	14.95
ADE-1H	+17	0.5-500	5.3	52	23	4	4.95
ADE-1HW	+17	5-750	6.0	48	26	3	6.45
ADEX-10H	+17	10-1000	7.0	55	22	3	3.45
ADE-10H	+17	400-1000	7.0	39	30	3	7.95
ADE-12H	+17	500-1200	6.7	34	28	3	8.95
ADE-17H	+17	100-1700	7.2	36	25	3	8.95
ADE-20H	+17	1500-2000	5.2	29	24	3	8.95

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DESIGN

Designing Antennas For UWB Systems

The Vivaldi antenna is an extremely broadband configuration that can be readily designed with modern CAD tools and fabricated with standard high-frequency substrate materials.

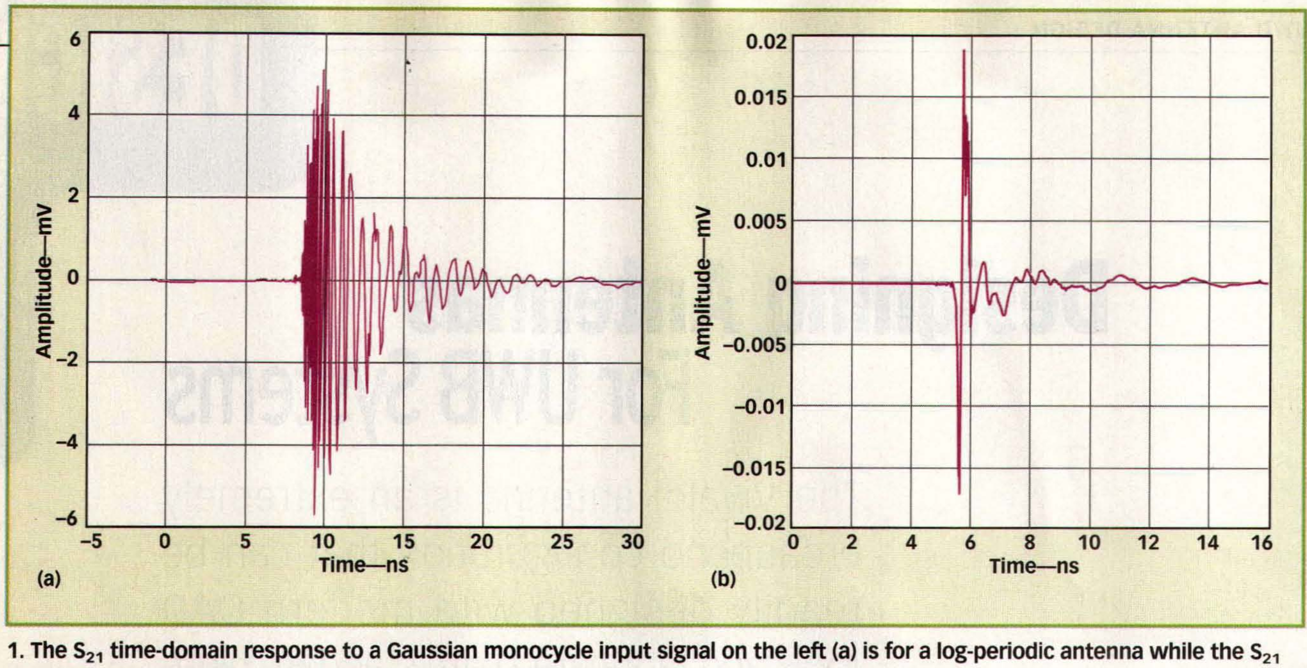
JOSEPH A.N. NORONHA
TIMOTHY BIELAWA
CHRISTOPHER R. ANDERSON
DENNIS G. SWEENEY
STANISLAV LICUL
WILLIAM A. DAVIS

Bradley Department of Electrical and Computer Engineering, Virginia Polytechnic Institute and State University, Blacksburg VA 24061-0111; (540) 231-2558, FAX: (540) 231-3004, e-mail: jnoronha@vt.edu , tbielawa@vt.edu , chanders@vt.edu , dsweeney@vt.edu , slicul@vt.edu , wadavis@vt.edu, Internet: www.vt.edu.

Ultrawideband (UWB) technology offers several advantages over conventional communications methods. For example, UWB systems feature information bandwidths of 1 GHz and more while being able to share spectrum with other applications without causing interference. UWB systems use narrow pulses to transmit data. Since no carrier frequencies are involved, the transmitter (Tx) and receiver (Rx) hardware can be made very simple. Still, a challenge lies in the development of an antenna capable of handling these high-speed pulse trains. UWB antennas must cover multiple-octave bandwidths in order to transmit pulses that are of the order of a nanosecond in duration. Since data may be contained in the shape of the UWB pulse, antenna pulse distortion must be kept to a minimum.

The Vivaldi antenna offers great promise for UWB applications. This planar design is suitable both for radar-like and communications applications. First conceptualized in 1979 as a wideband antenna,[1] the initial designs were balanced structures and therefore had to be fed by a wideband balun transformer. The primary disadvantage of this architecture is that the balun must provide good performance over the entire bandwidth of the transmitted signal, significantly increasing the implementation costs. The Vivaldi antenna is still in use today in its original form for broadband microwave and electronic-countermeasure (ECM) applications. Newer designs[2] involve the use of double-sided and stripline versions employing innovative techniques to eliminate the balun.

The Vivaldi antenna can preserve the shape of transmitted UWB pulses, ensuring error-free, high-data-rate communications. To understand why, **Fig. 1a** compares the time-domain S_{21} response for a Gaussian monocycle input when fed to a log-periodic dipole antenna (a classical broadband antenna structure) and a Vivaldi antenna. In the log-periodic antenna, the smallest antenna element radiates the highest-frequency component while the largest antenna element radiates the lowest-frequency component after the pulse has had time to propagate to the far end of the antenna. The use of these resonant elements, however, results in an antenna, which is dispersive in the time domain. The dispersion results in difficulties distinguishing individual multipath signals—a well-known advantage of UWB—at the Rx, due to broadening of the pulses resulting in significant overlap. **Figure 1b** shows the time-domain S_{21} response of a Vivaldi antenna. This antenna produces a near-



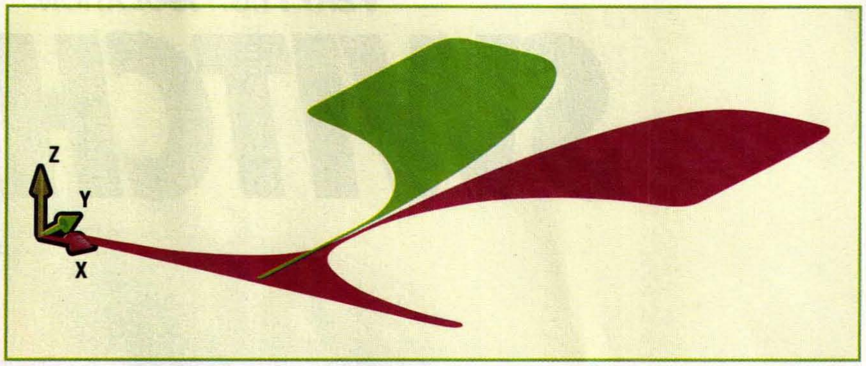
1. The S_{21} time-domain response to a Gaussian monocycle input signal on the left (a) is for a log-periodic antenna while the S_{21} time-domain response on the right (b) is for a Vivaldi antenna.

perfect Gaussian doublet in response to the Gaussian monocycle input, (i.e., the first-order derivative[3]), and has a greater efficiency than the log-periodic dipole antenna.

What follows is meant to guide the reader through an engineering analysis of the Vivaldi antenna, attempting to explain how the different aspects of

Vivaldi antenna design parameters and test results.

DESIGN PARAMETERS							MEASURED RESULTS	
ANTENNA NUMBER	PCB SUBSTRATE	PCB THICKNESS (MILS)	MICROSTRIP WIDTH (MILS)	MICROSTRIP LENGTH (INCH)	PAIRED STRIP WIDTH (MILS)	PAIRED STRIP LENGTH (INCH)	BANDWIDTH ($S_{11} < -10$ dB) (GHZ)	GAIN (dBi)
1	R04003C	60	155	3.2	184	0.6	1.6 – 20.0	10
2	R04003C	60	155	3.2	184	0.6	0.4 – 10.0	9
3	R04003C	32	76	3.2	184	1.2	3.1 – 20.0	9
4	RT5880	62	207	3.2	243	1.1	1.9 – 20.0	10
5	FR4	59	118	3.3	150	1.0	1.8 – 20.0	8
6	TMM10	60	81	3.3	98	1.1	1.5 – 18.0	8
7	FR4	59	81	6.6	150	2.0	0.5 – 10.0	5
8	R04003C	60	118	0.5	40	0.1	4.5 – 14.0	N/A



2. The versatile and broadband Vivaldi antenna features this configuration.

the antenna affect its performance, as well as provide a prototyping methodology to design and fabricate the antenna. Vivaldi antennas have been designed for diverse purposes from ranging to communications within the FCC approved limits.[4] The performance of several antenna designs were evaluated in an anechoic chamber, and the effects of several different designs will be reviewed.

The Vivaldi antenna is composed primarily of three different structures: a microstrip feed, a paired-strip middle section, and the radiating section. The design of the microstrip and radiating sections have a critical impact on the antenna performance, while the paired strip serves primarily as a transition region. Adjustments to the designs presented here can be made without causing a substantial loss in overall performance. **Figure 2** shows an image of the overall Vivaldi antenna.

Early Vivaldi designs[5] used longitudinal tapered slots on semirigid coaxial cable for the antenna feed. Although covering several octaves in bandwidth, this method is difficult to implement since the taper (100:1) which would have to be cut into the shield of the coaxial cable. A more elegant feed structure is a simple microstrip transmission line. The width of the microstrip is designed for a 50-Ω characteristic impedance for the type and thickness of dielectric material, using standard formulae.[6]

In the current design, the microstrip transmission line gradually tapers to a paired-strip transmission line. The transition region is responsible for connecting the highly capacitive feed structure to the inductive radiating section, and decouples the microstrip structure from the radiating portion of the antenna. It was empirically discovered that the transition region should be three to five wavelengths long to prevent a sharp discontinuity (and the resulting pulse distortion) between the feed and radiating regions. In addition, a properly designed transition region will convert the unbalanced feed into a balanced structure that can then be connected to the radiating region of the antenna. A detailed analysis and discussion of the paired strip structure can be found in ref. 7. The equation helps calculate the characteristic impedance of the paired strip as a function of width, dielectric constant, and thickness of substrate:

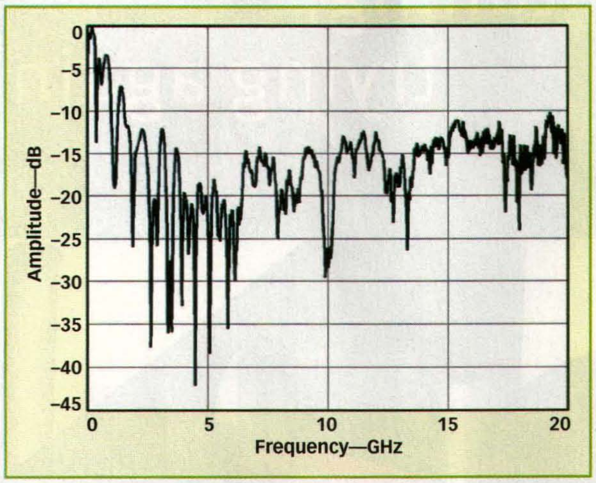
SEE EQUATION BELOW

where:

Z_0 = the characteristic impedance,
ϵ_r = the dielectric constant of the substrate,
ϵ_0 = the characteristic impedance of free space (377 Ω),
a = the width of the paired line × 0.5, and
b = the thickness of the dielectric substrate × 0.5.

$$Z_0 = \frac{\eta_0}{\sqrt{\varepsilon_r}} \left\{ \frac{a}{b} + \frac{1.0}{\pi}\ ln\ 4 + \frac{\varepsilon_r + 1.0}{2\pi\varepsilon_r}\ ln \left[\frac{\pi e \left(a/b + 0.94 \right)}{2.0} \right] + \frac{\varepsilon_r - 1.0}{2\pi\varepsilon_r^2}\ ln \frac{e\,\pi^2}{16.0} \right\}^{-1} \Omega\left(a/b > 1\right)$$

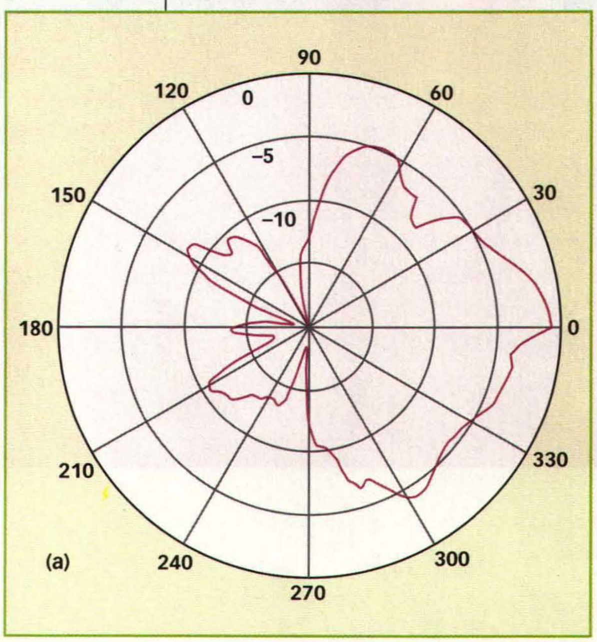
The paired-strip section is slowly tapered away on each side to develop into the radiating sections of the antenna. The taper into the radiating section of the antenna is the most critical aspect of the design. The taper should be as gradual and as smooth as possible to avoid significant discontinuities at higher frequencies, which will cause reflections resulting in a distorted pulse-shape.



3. These return-loss measurements were made for Vivaldi Antenna 1 using 0.062-in. (0.157-cm)-thick RO4003C substrate material.

Two types of curvatures were investigated for the taper: an elliptical transition and a spline transition. The elliptical transition uses two-quarter ellipses with the same-length minor axis but different-length major axes to form the shape of the radiators. The spline transition follows the same general shape as the ellipse, but attempts to achieve a better transition by varying the rate of the curvature as the spline progress, something that cannot be done with an ellipse. A spline appeared to provide the best time-domain response, although the elliptical taper provides equal magnitude electric (E) and magnetic (H) fields. Because good time-domain response is critical in a UWB system, the spline transition was of primary interest.

Using the basic parameters described above, a designer can come up with a suitable antenna using a standard computer-aided-design (CAD) package such as AutoCAD™. The antenna can also be simulated with the use of electromagnetic (EM) simulation tools, such as Sonnet™ from Sonnet Software (Liverpool, NY), by importing the design from the CAD package. For this article, eight antennas were designed; the major parameters are summarized in the **table**. The radiating region of Antenna 2 has an elliptical taper; all other antennas used a spline curvature. The spline curvature was created using AutoCAD's SPLINE function with a start point at the end of the paired strip and an endpoint at the end of the antenna. Antennas 7 and 8 were designed to cover the frequency range of 0.3 to 10 GHz and 3 to 10 GHz; all others were designed to cover 1 to 20



4. These are the normalized azimuth (a) and elevation (b) patterns for Vivaldi Antenna 1.

3D EM Simulation

GHz. Antennas 1 through 6 had an overall size of 8 × 11.5 in. (20.32 × 29.21 cm), Antenna 7 was 16 × 23.5 in. (40.64 × 59.69 cm), and antenna 8 was 1 × 3 in. (2.54 × 7.62 cm).

To facilitate a rapid design cycle, the antennas were fabricated in-house using a Protomat® 91s/Vs printed-circuit-board (PCB) milling/drilling machine from LPKF Laser and Electronics (Wilsonville, OR). For each antenna, the milling machine was used to mill the antenna outline on the copper-clad substrate. Commercially available adhesive-backed paper was then used to mask off the antenna element, and the remaining copper was chemically etched away. This in-house prototyping technique allowed us to go from initial design to finished antenna in about 1.5 h.

Each of the antennas was then evaluated in an anechoic chamber to determine the S-parameters both in the time and frequency domains. These measurements provided the time-domain impulse response (Fig. 1, for example) along with the antenna efficiency and return loss from 0.1 to 20 GHz. The measurements were conducted in the frequency domain using an 8510 network analyzer with the time-domain option from Agilent Technologies (Santa Rosa, CA) and then converted into the time-domain using an inverse Fast Fourier Transform (IFFT). Including testing, approximately 4 to 6 antennas could be designed and evaluated in a single workday, whereas EM simulations required up to several days for each antenna design.

In order to provide a complete study of the antennas, they have been categorized into two applications: communications and ranging/measurements. The communications-specific antennas were designed using RO4003C materials [0.060-in. (0.1254-cm) thickness and relative dielectric constant of 3.38] from Rogers Corp. (Rogers, CT). The design focused on optimizing performance in the 3.1-to-10.6-GHz range to satisfy the FCC First Note and Order specifications with regards to short-range communication systems. Additionally, these antennas are primarily intended for short-range mobile communications or distributed sensor networks and, as a result, a primary design criterion involved minimizing the overall size of the antenna while maintaining an acceptable level of performance.

The second type of antenna was designed for ranging/radar/channel sounding applications. In this case, the primary design criterion was an antenna that operated over several octaves in bandwidth (0.3 to 20 GHz). For UWB channel-sounding applications, it is highly desirable to decouple the antenna effects from the measured channel, in order to obtain the true impulse response of the channel. The use of classical broadband antennas, such as the log-periodic or Archimedean spiral complicates the decoupling process due to the distortion in the radiated pulse. Antennas such as the transverse-electromagnetic (TEM) horn and Vivaldi antenna impart a minimal amount of pulse distortion; however, the Vivaldi can be integrated onto the same circuit board as the Tx and Rx electronics, resulting in a more compact and portable measurement system.

The eight Vivaldi antennas were measured in the Virginia Tech anechoic chamber and an outdoor free-space antenna range from 50 MHz to 20 GHz (see table). Vivaldi antenna s fabricated on the R04003 and RT5880 substrates had the widest bandwidth, although the antennas fabricated on the FR4 material still performed adequately within the 3.1-to-10.6-GHz UWB spectrum. Antenna 1 was by far the best-performing design, with a bandwidth of over 18 GHz, and a gain of 10 dBi. **Figure 3** shows the return loss (S_{11}) of Antenna 1, and **Figures 4(a) and 4(b)** show the azimuth and elevation patterns. Although the Vivaldi is a directional antenna, it has a very broad main beam in both the azimuth and elevation planes, and contains several relatively high sidelobes in the back of the antenna.

Antenna 8 was designed to be a compact antenna specifically for portable UWB applications such as laptop computers or distributed sensor networks.

Even with its relatively small size, Antenna 8 performed reasonably well over most of the UWB spectrum, and could be easily integrated with Tx/Rx hardware. In short, the Vivaldi antenna is an excellent candidate for UWB applications. It offers good performance in terms of bandwidth, low pulse distortion, and ease of implementation. The antenna can be fabricated on commonly available PCB substrates can be integrated with other portions of the transceiver thus providing for an elegant and compact design. MRF

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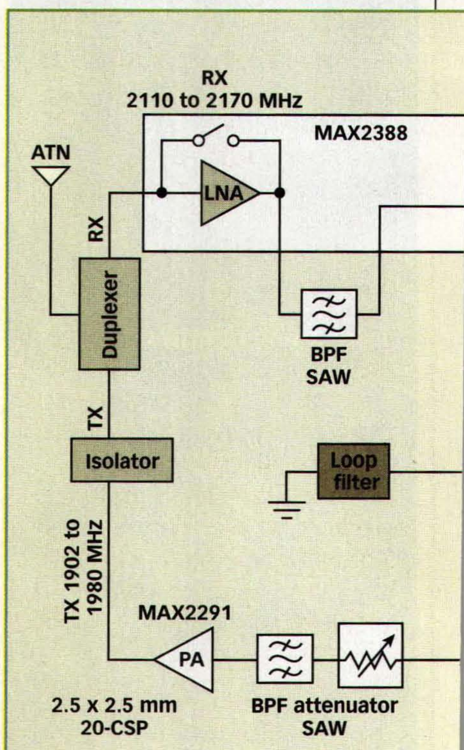
Tracking WCDMA Transmitter Theory

This WCDMA reference design helps to demonstrate the effects of different power levels on EVM, ACP, and other key transmitter performance parameters.

PAUL KIMULI
Senior RF Applications Engineer
Maxim/Dallas, Unit 3, Theale Technology Centre, Station Rd., Theale, Berkshire RG7 4XX, England; +44-2087641225, FAX: +44-208 764 235, e-mail: pserukenya@hotmail.com, Internet: www.maxim-ic.com.

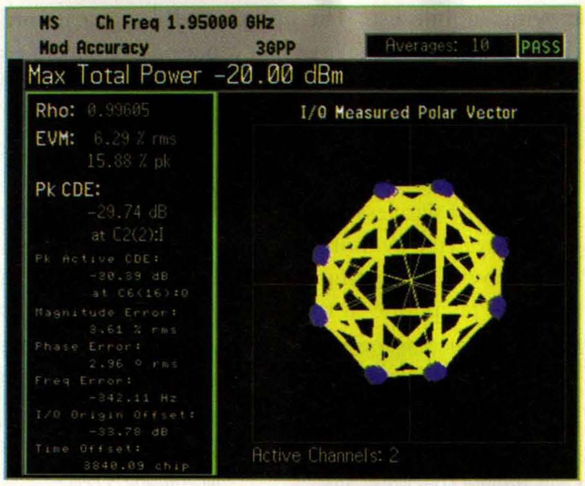
Third-generation (3G) wireless communications systems are designed to improve upon the performance and services available from their first- and second-generation (1G and 2G) predecessors. The goal of 3G systems is true seamless global mobile communications sharing full compatibility with selected access technologies such as wireless local loop (WLL), cellular, cordless, and satellite-communications systems. One technical challenge to the advent of seamless global-terminal mobility is the difficulty in achieving a common global-frequency plan. In every world region, at least part of the necessary spectrum is already allocated for other radio services.

Following a spectrum allocation around 2 GHz (roughly 1880 to 2200 MHz, depending upon geographic region) by the World Administrative Radio Conference (WARC) in 1992, the International Telecommunication Union—Radio-communication sector (ITU-R) began to define a wish list for 3G-system requirements. A range of technologies were proposed to meet these requirements, including orthogonal frequency-division multiplex (OFDM), opportunity-driven multiple access (ODMA), time-division synchronous code-division multiple access (TDSCDMA), and wideband CDMA



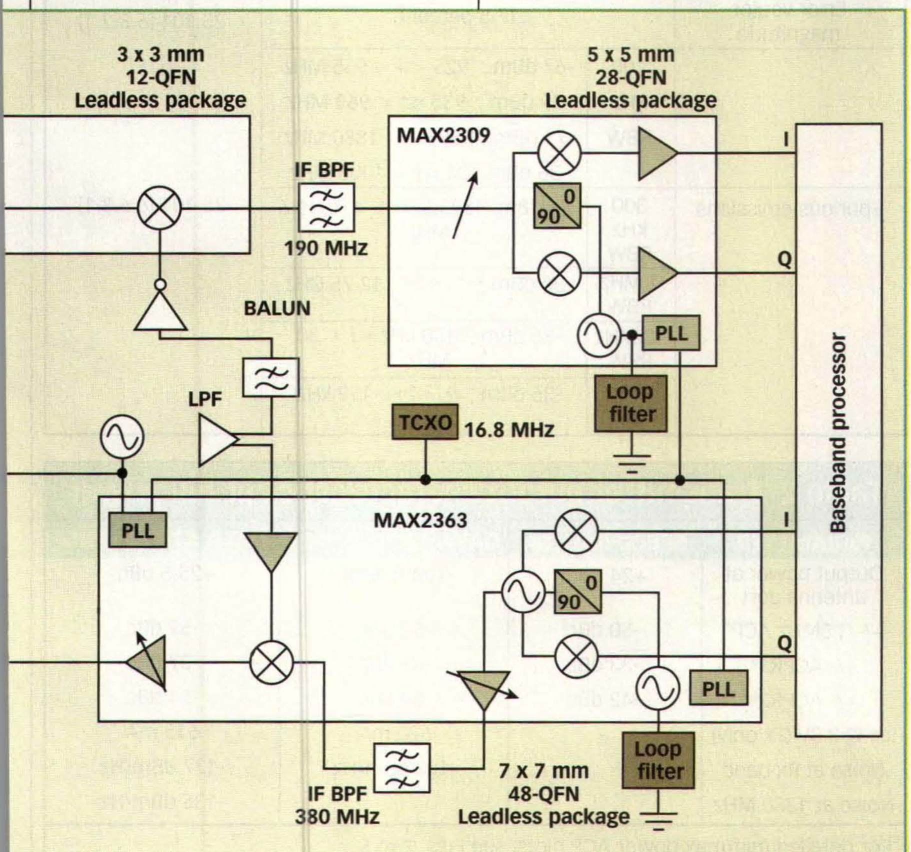
1. This block diagram shows a typical WCDMA transceiver based on standard packaged integrated circuits (ICs).

(WCDMA). A technical body called the Third-Generation Partnership Project (3GPP) was organized to analyze the proposed technologies, with WCDMA selected as the preferred technology for 3G systems. The 3GPP standards organization has since written a technical-requirements specification in which chapter 25.101 includes the key performance requirements for the RF hardware portion of a WCDMA mobile terminal.



2. The error-vector magnitude (EVM) of the reference design's transmitter strip was evaluated at –20 dBm.

The 3GPP also defined two choices of operation for a WCDMA terminal: a frequency-division-duplex (FDD) mode and a time-division-duplex (TDD) mode. In the former, physical channels are defined by the RF channel number and the channelization code. The FDD mode is suitable for fast-moving mobile use. The uplink and downlink functions are separated in the frequency domain, and the approach offers greater downlink capacity then uplink capacity. The FDD approach employs a 100-percent duty cycle on both the uplink and downlink functions. In the TDD mode, physical channels are defined by the RF channel number, the channelization code, and the time slot. This approach is suitable for indoor or slow-



moving mobile use. The uplink and downlink functions have similar capacities and occupy the same channel, with discontinuous transmission (DTx) on both the uplink and downlink.

DTx is a method for optimizing the efficiency of wireless voice-communications systems by momentarily powering-down or muting a mobile or portable telephone in the absence of voice input. In a typical two-way conversation, each party speaks slightly less than one-half the time, so if a transmitter (Tx) is on during voice input only, the telephone's duty cycle can be cut to less than 50 percent. This conserves battery power, eases the workload of Tx components, and frees time for the channel—allowing the system to take advantage of available bandwidth

Table 1: Transmitter requirements for 3GPP

PARAMETER	3GPP SPECIFICATION		REFERENCE
RF range	1920 – 1980 MHz		25.101 [5.2]
Channel spacing	Nominally 5 MHz		
Chip rate	3.84 Mcps		
Maximum output power	+24 dBm +1/- 3 dB [power class 3]		25.101 [6.2]
Minimum output power	-50 dBm		25.101 [6.4.3.1]
Transmit off power	< -56 dBm		25.101 [6.5.1.1]
Adjacent channel leakage power	> -33 dBc [if adjacent channel power is > -50 dBm]		25.101 [6.6.2.2.1]
Alternate channel leakage power	>-43 dBc		25.101 [6.6.2.2.1]
Frequency error	Within +/- 0.1ppm		25.101 [6.3]
Transmit intermodulation	> -31 dBc [@5-MHz offset] > -41 dBc [@10-MHz offset]		25.101 [6.7.1]
Error vector magnitude	<17.5 percent		25.101 [6.8.2.1]
Spurious emissions	100 kHz RBW	-67 dBm ; 925 ≤f ≤ 935 MHz	25.101 [6.6.3.1]
		-79 dBm ; 935 ≤f ≤ 960 MHz	
		-71 dBm;1805 ≤f ≤ 1880 MHz	
		-36 dBm ; 30 ≤f ≤ 1000 MHz	
	300 kHz RBW	-41 dBm; 1893.5 ≤ f ≤ 1919.6 MHz	
	1 MHz RBW	-30 dBm ; 1 ≤f ≤ 12.75 GHz	
	10 MHz RBW	-36 dBm ; 150 kHz ≤f ≤ 30 MHz	
	1 kHz RBW	-36 dBm ; 9 ≤f ≤ 150 kHz	

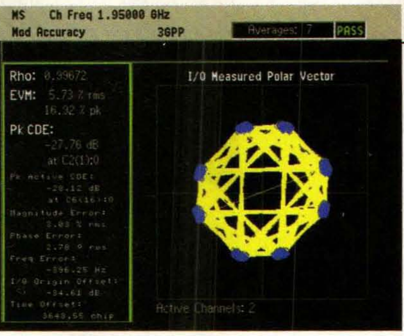
Table 2: Transmitter output characteristics at full power

PARAMETER	SPECIFICATION	DATA AT 1980 MHZ	DATA AT 1920 MHZ
Output power at antenna port	+24 dBm	+24.8 dBm	+25.5 dBm
+/- 3.8MHz ACP[a]	-50 dBc	-52 dBc	-52 dBc
+/- ACPR1[a]	-33 dBc	-37 dBc	-37 dBc
+/- ACPR2[a]	-42 dBc	-54 dBc	-54 dBc
Icc @ 3.3V (Tx only)	-	620 mA	615 mA
Noise at Rx band		-137 dBm/Hz	-137 dBm/Hz
Noise at 1880 MHz			-135 dBm/Hz

[a]For detailed min/max power ACP plots, see Figs. 2 to 5.

by sharing the channel with other signals. DTX circuits operate with voice-activity detection (VAD), which in wireless Txs is sometimes called voice-operated transmission (VOX). The 3GPP specifications also include FDD terminals for 60-MHz chunks only, with 190-MHz duplex spacing: 2110 to 2170 MHz for mobile receive and 1920 to 1980 MHz for mobile transmit.

Chapter 25.101 of the 3GPP specification covers the receive and transmit electrical requirements for FDD 3G mobile terminals. Before exploring WCDMA Tx requirements, it may help to review some of the key Tx parameters and their importance in Tx design. Adjacent-channel power ratio (ACPR), for example, is a measure of the amount of interference or power in an adjacent-frequency channel. Usually defined as the ratio of the average power in the adjacent frequency channel (or offset) to the average power in the transmitted-frequency channel, ACPR describes the amount of distortion due to nonlinearities in the Tx hardware.



3. The error-vector magnitude (EVM) of the reference design's transmitter strip was evaluated at –24 dBm.

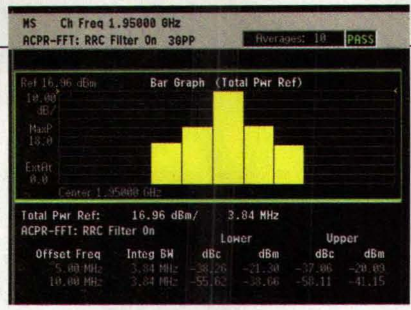
ACPR is critical for WCDMA Txs, because CDMA modulation produces closely spaced spectral components in a modulated carrier. Intermodulation of those components causes a spectral regrowth of "shoulders" around the center-carrier frequency. Nonlinearities in the Tx can disperse those spectral-regrowth components into adjacent channels.

Error vector magnitude (EVM) is the vector (magnitude and phase) difference at a given instant between an ideal error-free reference and the actual transmitted signal. Because it changes continuously during every symbol transition, EVM is defined as the root-mean-square (RMS) value of the error vector over time. EVM is critical for WCDMA Tx performance because it indicates modulation quality in the transmitted signal. A large value of EVM results in degraded transceiver performance by causing poor detection accuracy.

Frequency error is the difference between specified and actual carrier frequencies. A large frequency error degrades transceiver performance by causing adjacent-channel interference and poor detection accuracy. Spurious and harmonic signals are tones pro-

duced by different signal combinations in the Tx, and harmonics are distortion products produced by nonlinear behavior in the Tx. Harmonics occur at integer multiples of the transmitted signal.

Table 1 shows key requirements for specifying and designing 3G WCDMA Tx terminals. These requirements are met by a variety of ICs from Maxim Integrated Products (Sunnyvale, CA), including the MAX236X superheterodyne IC, using a typical Tx IF of 380 MHz. The company's MAX2383 upconverter driver has also been developed for superheterodyne architectures; it handles transmit IFs to 570 MHz.

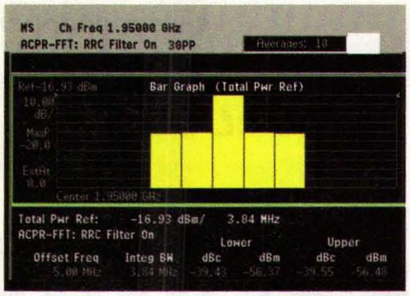


4. The adjacent-channel power (ACP) of the reference design's transmitter strip was evaluated at +24 dBm.

As part of a complete WCDMA transceiver, a Tx reference design was developed based on commercial hardware **(Fig. 1)**. The reference design includes the MAX2388 receive front end, the MAX2309 intermediate-frequency (IF) quadrature demodulator, the MAX2363 quadrature modulator/upconverter Tx, and the MAX2291 RF power amplifier (PA). The Tx assumes an IF of 380 MHz and a transmit frequency of 1920 to 1980 MHz. A duplexer filter allows full-duplex operation by connecting the transmit path (and receive path) to an antenna.

At the back-end of the Tx, the MAX2363 accepts baseband-transmit I and Q differential-input signals as inputs, and performs quadrature modulation, IF and RF LO synthesis, and RF upconversion. The IF LO is synthesized by an internal VCO and PLL running at 760 MHz. An external RF VCO module allows high-side injection of −7 dBm into the MAX2363 upconverter IC. On-chip RF drivers allow the chip to drive an external PA directly.

At the front-end of the Tx, a chip-scale-packaged linear PA (model MAX2291) provides 28 dB gain and as



5. The adjacent-channel power (ACP) of the reference design's transmitter strip was evaluated at −20 dBm.

much as +28 dBm output power at 1-dB compression. With a post-PA insertion loss of approximately 4 dB, the system achieves maximum antenna output of +24 dBm. Since mature WCDMA systems are expected to operate typically at mid-power rather than full-power levels, the MAX2291 addresses this requirement via two (low- and high-power) optimized output-power modes. Measurements in the high-power mode, with V_{cc} at +3.5 VDC, show output power of +28 dBm at 1.95 GHz, ACPI of –39 dBc (measured at a 5-MHz offset within a 3.84-MHz channel), power-added efficiency of 37 percent, and idle

Error vector magnitude (EVM) is the vector (magnitude and phase) difference at a given instant between an ideal error-free reference and the actual transmitted signal.

I_{cc} of 97 mA. Measurements in the low-power mode, with V_{cc} at +3.5 VDC, reveal output power of +16 dBm at a frequency of 1.95 GHz, ACPI of –38 dBc (measured at a 5-MHz offset in a 3.84-MHz bandwidth), power-added efficiency of 14 percent, and idle current, I_{cc}, of 30 mA.

The 3GPP specification calls for WCDMA Tx power between –50 and +24 dBm, a 74-dB dynamic range. Allowing for some margin, version 1 of the WCDMA Tx reference design achieves better than 80-dB dynamic range. The dynamic range of a Tx chip is limited, usually by ACPR at the high-power end and by the noise floor at the low-power end. To obtain more than 15 dB carrier-to-noise (C/N) ratio at the low-power end, an additional 20 dB of variable attenuation (introduced by a gain-control attenuator for the PA) was designed into version 1 of the reference design. Key performance

parameters extracted from extensive test results **(Table 2)** verify the suitability of Maxim's Tx reference design.

An EVM of approximately 5.7 percent was measured at +24 dBm Tx output power from the reference design (attributing 3.5 percent to the MAX2291 PA and 4.6 percent to the MAX2363 Tx chip). The overall EVM value is well within the 3GPP requirement (less than 17.5 percent). Measurements on the EVM and ACP for the transmit strip were as follows: transmit strip EVM at –20 dBm **(Fig. 2)**, transmit strip EVM at +24 dBm **(Fig. 3)**, transmit strip ACP at +24 dBm **(Fig. 4)**, and transmit strip ACP at –20 dBm **(Fig. 5)**.

Based on a suburban voice-output power-distribution function (a statistical figure of merit that describes power variation according to urban versus rural, data versus voice, etc.), the transmit strip current measures 550 mA at maximum output power, and 365 mA at +22 dBm. The Tx noise in the receive band measures –137.0 dBm/Hz at maximum Tx power. If the isolation between the Tx and receiver (Rx) is 50 dB, the calculated Tx noise in the receive path is –187.0 dBm/Hz, which is much lower than the thermal noise. That is, the Tx contributes almost nothing to the total Rx noise. (This calculation has been verified by supporting measurements at maximum and reduced power.)

Typical frequency-domain spectral masks (not shown) reveal signal levels expected at the reference design's antenna port. For +24 dBm antenna output power, the conditions are I_{cc} of 490 mA for transmit only and 535 mA for transmit and receive, a MAX2363 IF DAC setting of 110, and V_{GC} of 2.4 V. For –53 dBm antenna output power (i.e., low Tx output power for which V_{GC} = 1.35 V and the absolute output power is –38 dBm) electrical conditions include I_{cc} of 166 mA (for Tx only), V_{GC} of 1.35 V, IF DAC at 000, PA bias setting of 1, and output-power attenuation set at maximum. MRF

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2. Maxim website: http://dbserv.maxim-ic.com/an_prodline2.cfm?prodline=14

RF MEMS: Theory, Design, and Technology

GABRIEL M. REBEIZ

MICROELECTROMECHANICAL SYSTEMS (MEMS) offer tremendous potential in a variety of application areas, including automotive, telecommunications, and medical uses. In addition, MEMS technology is well suited for a wide range of RF and microwave components, such as switches, attenuators, and phase shifters. In *RF MEMS: Theory, Design, and Technology*, Gabriel Rebeiz explores some of the promise offered by this unique technology for high-frequency circuits and components. Rebeiz, a professor of Electrical Engineering and Computer Science at the University of Michigan (Ann Arbor, MI), leads a research group on RF MEMS and high-speed RF integrated-circuit (IC) technologies.

By 2001, more than 30 companies were working on their own versions of RF MEMS components, including Analog Devices, Motorola, NEC, and ST-Microelectronics. Rebeiz categorizes RF MEMS research into four areas: switches, varactors, and inductors; micromachined transmission lines, high-Q resonators, filters, and antennas; film bulk acoustic resonators (FBARs) and filters based on acoustic effects; and RF micromechanical resonators and filters that use the mechanical vibration of small beams to achieve high-Q resonances. *RF MEMS: Theory, Design, and Technology* focuses solely on the first category of RF MEMS, examining in great deal the operating principles, fabrication, packaging, modeling, and reliability of RF MEMS switches, varactors, and inductors.

The book's opening chapter offers several case studies of RF MEMS switches, including those used for low-noise, low-power circuits and those for portable wireless systems. Subsequent chapters cover mechanical modeling of MEMS devices through static analysis, mechanical modeling of MEMS devices through dynamic analysis, electromagnetic (EM) modeling of MEMS switches, a MEMS switch library, MEMS switch fabrication and packaging, a study of switch reliability and power-handling limitations, the design of MEMS switch circuits, MEMS phase shifters, MEMS varactors and tunable oscillators, micromachined inductors, reconfigurable MEMS networks (including filters and antennas), and noise effects in MEMS devices.

For those beginning their research on RF MEMS, this text is an invaluable addition to the research library, and highly recommended for all interested in this fascinating technology. (2003, 483 pp., hardcover, ISBN: 0-471-20169-3, $89.95.) **John Wiley & Sons, Inc., 111 River St., Hoboken, NJ 07030; (201) 748-6000, FAX: (201) 748-6088, Internet: www.wiley.com.**

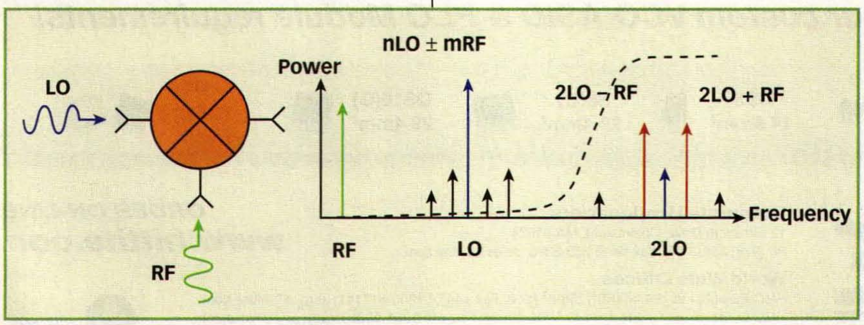
Optimize Benefits Of Subharmonic Mixers

Software design tools can help simply the challenge of creating subharmonic mixers that provide the full advantages of their unique characteristics.

TONY DONISI
Senior Applications Engineer
Ansoft Corp., 4 Station Square, Suite 200, Pittsburgh, PA 15219; (412) 261-3200, FAX: (412) 471-9427, e-mail: tdonisi@ansoft.com, Internet: www.ansoft.com.

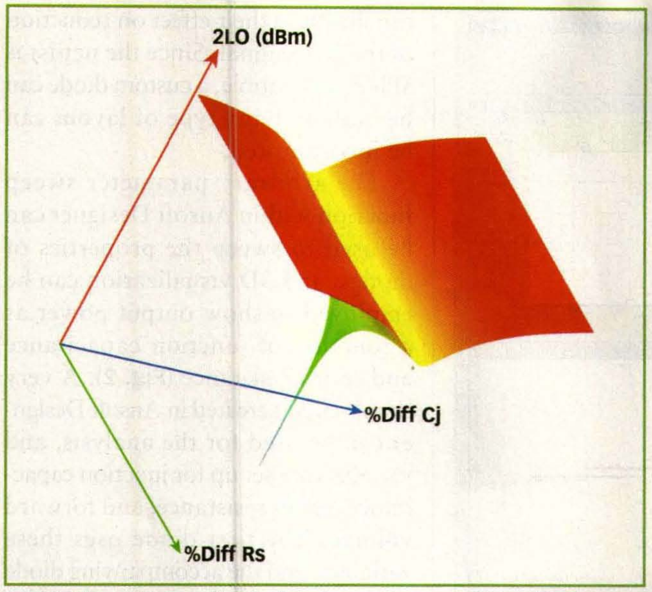
Subharmonic mixers are attractive for millimeter-wave systems, at frequencies where signal generation is expensive. Such mixers are often used in applications above 30 GHz, such as digital microwave radios, and even called upon in support of scientific applications working as high as 200 GHz. While the design of subharmonic mixers is relatively difficult, optimizing their performance can be greatly facilitated by the use of electronic-design-automation (EDA) tools. To illustrate how these tools can benefit the design process, a subharmonic mixer with an RF output of 28.1 GHz was created using the Ansoft Designer™ suite of software tools.

Subharmonic mixers benefit from the capability of working with a local-oscillator (LO) frequency that is a fraction of the frequency of incoming RF signals. For example, a system operating at 38 GHz with a second-subharmonic mixer requires an LO of only 19 GHz, which is considerably easier to design and less expensive to obtain than an LO operating closer to the nominal RF. To operate with even lower-frequency LOs, higher-order subharmonic mixers can also be used. In this same example, a fourth-subharmonic mixer would require an LO of only 9.5 GHz. Subharmonic mixers inherently provide 50-to-60-dB rejection of the even harmonics of the LO signal at the RF output, which reduces the amount of LO rejection (filtering) that must designed into in the circuit. A typical subharmonic mixer spectrum is shown in **Fig. 1**.



1. A subharmonic mixer typically generates these spurious products. RF signals mix with the LO's second harmonics to create 2LO – RF and 2LO + RF products.

Although offering obvious cost benefits, subharmonic mixers have been traditionally difficult to design. They have inherent characteristics that must be accommodated in order to achieve the desired performance. For example, subharmonic mixers have higher conversion loss than their single- or double-balanced counterparts, and the higher-order spurious responses that they produce must be minimized. Nevertheless, through careful design aided by electromagnetic (EM) simulation, conversion



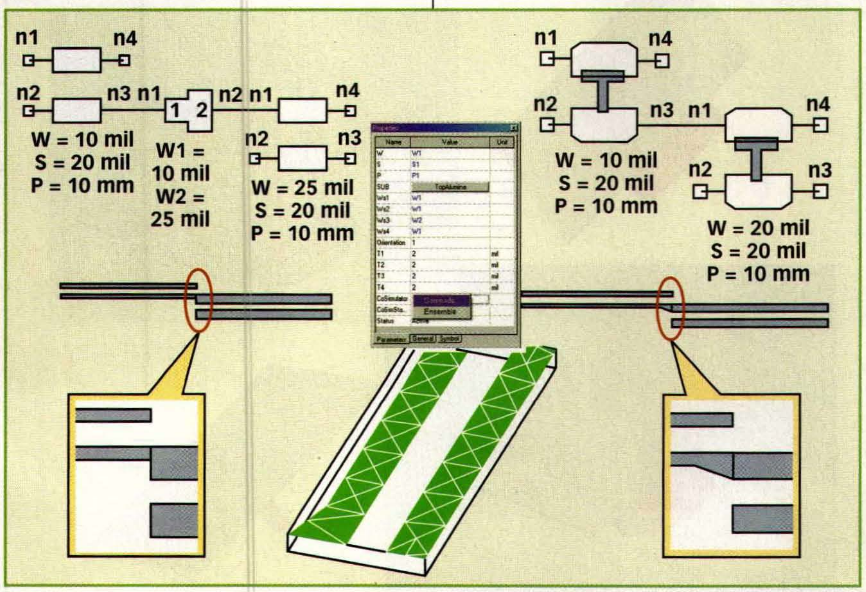
2. This three-dimensional plot shows the variation of 2LO attenuation versus percent difference of diode junction capacitance and forward voltage.

loss can be controlled to only slightly more than that of balanced mixer designs, and their spurious responses can be well characterized, allowing the significant benefits of this type of mixer to be realized to their fullest.

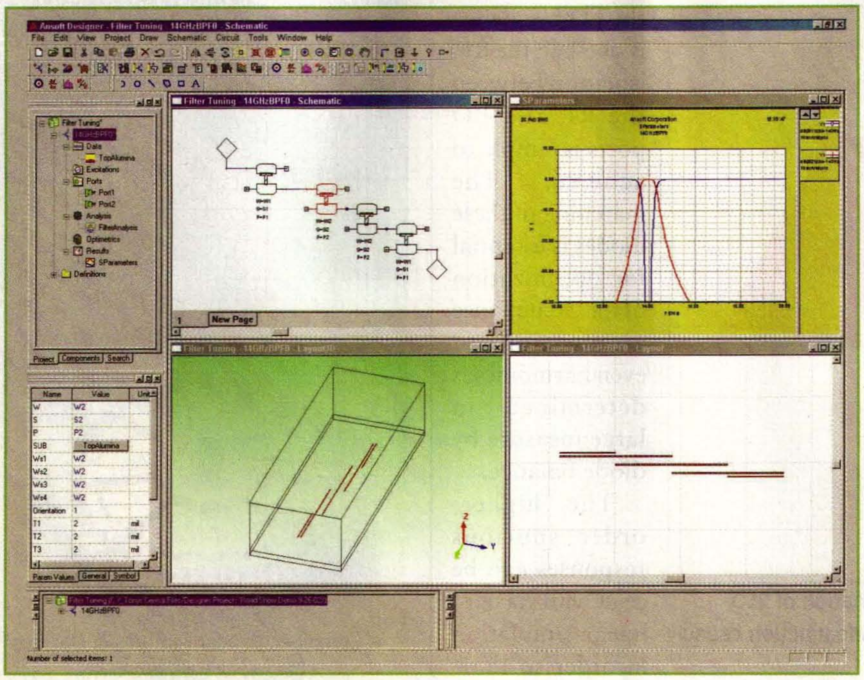
Subharmonic mixers use an antiparallel diode pair to generate a nonlinear conductance waveform at twice the frequency of the LO signal. Since the LO frequency is one-half the RF, isolation between the RF and LO ports is simple to achieve. The matching of these diodes is essential for optimization of the circuit, since attenuation of even harmonics is determined in large measure by diode balance.

The higher-order spurious responses can be dealt with via nonlinear simulation in order to thoroughly characterize harmonic content and achieve accurate harmonic balance. Since the spectral location of the responses must be found, the harmonic-balance software engine can be set to address them. In order that all of these low-level harmonic responses are properly identified, the simulation software must have an extremely low noise floor.

A mixer for study was chosen to



3. This screen shows a Solver-On-Demand coupled-line component with smooth transitions, and a schematic representation, layout, properties, and three-dimensional view with the planar EM mesh.



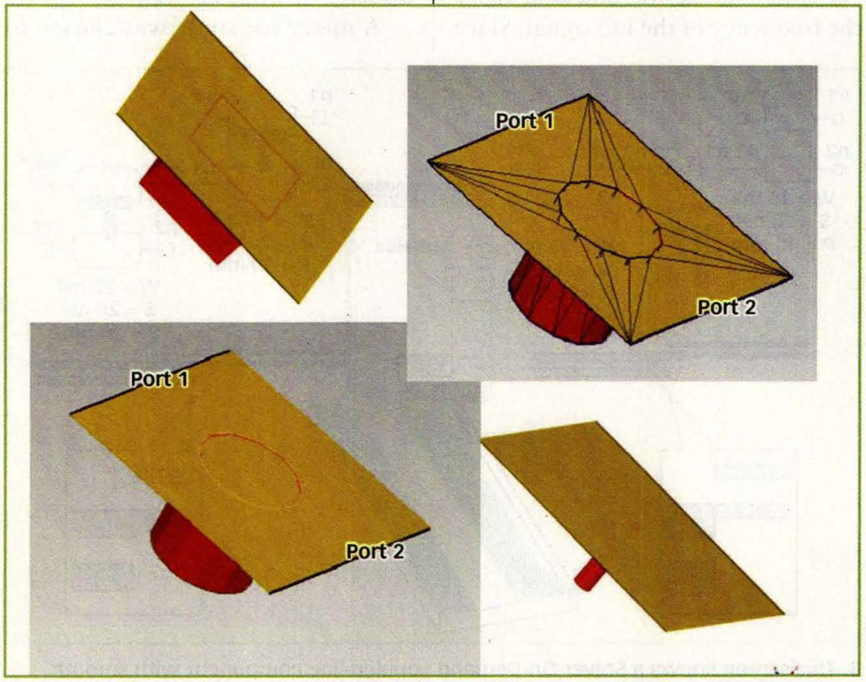
4. This screen shows an LO filter design using custom MCPL components, complete with schematic and filter S-parameter plots.

be on a 5-mil-thick alumina substrate, using a flip-chip-mounted diode pair and spiral inductors. Selecting the diodes requires an analysis of their responses as functions of voltage and other parameters. Such mixer diodes are widely available in surface-mount-technology (SMT) beam-lead, and flip-chip versions and, since they are obtained from adjacent sections of the wafer, their characteristics are generally quite well matched. SPICE parameters for such diodes are generally available from most manufacturers. Modeling data for all package types can be imported into the simulation software, parameterized if desired, and two- and three-dimensional (2D and 3D) layouts can be realized. For this example, SMT Schottky diodes from Skyworks Solutions (Woburn, MA) were selected, accompanied by SPICE parameters for modeling purposes.

Ansoft Designer makes it simple to create nonstandard components, in this case an antiparallel diode pair. While diode manufacturers generally supply five or six key parameters, only three characteristics—series resistance, junction voltage, and junction capacitance—have a substantial effect on diode balance, so the remainder of the parameters can be considered constant from diode to diode in the SPICE model. Each diode is given different value of each critical parameter so that the variations can illustrate their effect on reduction of the 2LO signal. Since the netlist is SPICE compatible, a custom diode can be built and any type of layout can be incorporated.

The arbitrary parameter sweep function within Ansoft Designer can be used to sweep the properties of diodes, and 3D visualization can be employed to show output power as a function of junction capacitance and series resistance **(Fig. 2)**. A very simple circuit created in Ansoft Designer can be used for the analysis, and variables are set up for junction capacitance, series resistance, and forward voltage. The first diode uses these variables, and the accompanying diode in the pair can be characterized as a "percent difference" from the first. The percent difference in each parameter is then varied and plotted in both 2D and 3D formats.

The 3D plot in Fig. 2 clearly shows how output power varies with junction capacitance and series resistance. One axis is the junction capacitance and the other is series resistance and output power. The spike at the center of the output power is the precise point at which the diodes are per-



5. Typical planar EM via holes are shown meshed in the Z direction as well as the X-Y direction.

fectly balanced (and maximum rejection of even harmonics occurs). Performance drops off precipitously as series resistance and junction capacitance increase.

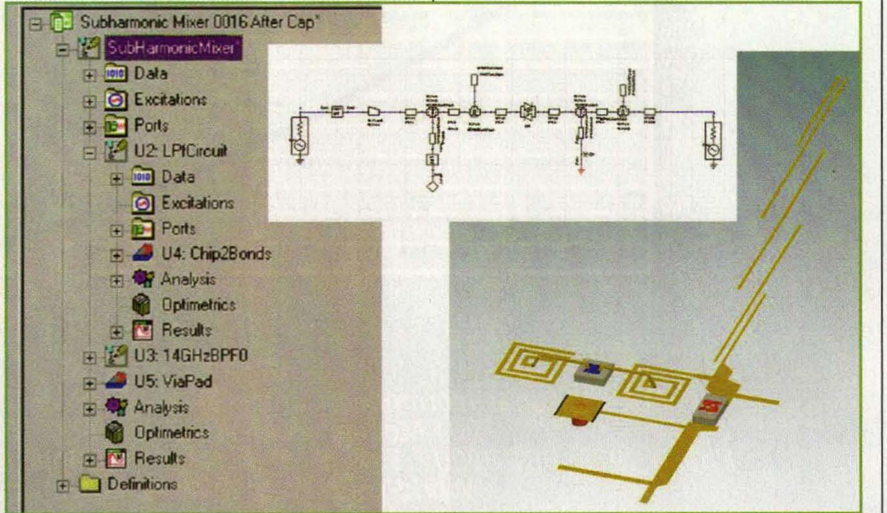
The upconverting subharmonic mixer configuration that was modeled in this article features an LO frequency of 14 GHz, RF output of 28 GHz, intermediate-frequency (IF) input of 100 MHz, a bandpass filter at the LO frequency, phased properly with the diode pair, output stubs for rejection at the LO and 3LO frequencies, a stub for rejection of 3LO frequencies at the input port, and an LC filter in the LO arm terminated at the RF arm in order to screen IF input signals.

Creation of several mixer components is aided by Ansoft Designer's Solver on Demand technology. This is a particularly important capability when creating microstrip coupled-line steps and transitions, which are traditionally limited to the tried-and-true shapes that have served designers for decades.

Ansoft Designer's embedded planar EM solver also aids creation of several mixer components. Using the unique Solver-on-Demand technology, engineers can directly define and model circuit components based on arbitrary geometries and insert these components into their larger networks. This allows engineers the freedom of utilizing novel, better-performing topologies without paying the price of uncertain model behavior. This is a particularly attractive feature when creating optimum performing microstrip coupled-line steps and transitions that traditionally are based on abrupt step changes due to modeling concerns.

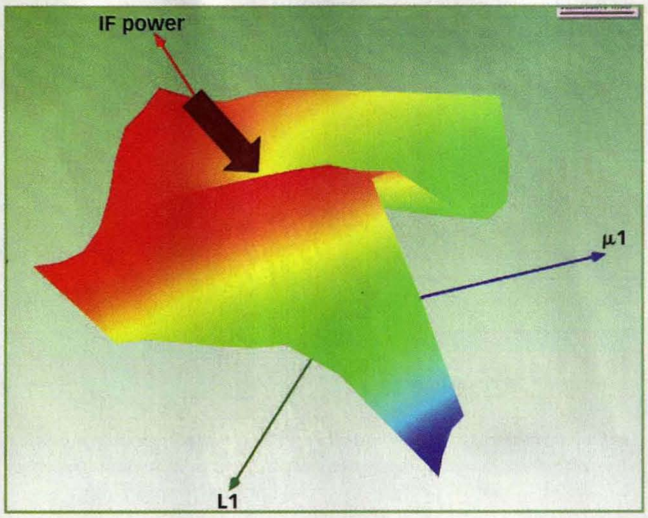
Since abrupt steps are undesirable at high frequencies, a designer wishing to create a nonstandard topology normally must rely on a tedious trial-and-error process. In addition, the orientation step in the layout process can also be time-consuming. With the Solver-on-Demand technology, designers can quickly create custom shapes represented by accurate models, eliminating the need to rely on circuit equivalents. Solution caching in Ansoft Designer automatically embeds planar EM solutions for all instances of that Solver-on-Demand component in a network with the results of a single EM simulation, reducing the overall simulation time.

An edge-coupled filter provides an excellent example of this capability. A coupled-line filter always has a critical junction, the effect of which must be minimized usually through a step that often still results in an unde-



6. The complete mixer design is shown here, including the schematic diagram, three-dimensional view, and the project tree. All the circuits and subcircuits are accessible through this tree, and can be analyzed independently.


INMET



7. This three-dimensional plot shows variations of IF output power versus changes in two critical variables. The best design point would be the flat section as indicated by the arrow.

sirable discontinuity. Since the Solver-On-Demand technology allows any type of component or model to be created, a custom taper can be used instead of a step.

By defining a microstrip coupled line with a custom width and separation that is layout compatible (allowing it to transition into the next section), the effect of this junction on performance can be significantly minimized. Since Ansoft Designer is netlist based, a circuit equivalent can be created that contains common components for faster analysis. This netlist fragment is part of the component definition. The netlist shows four step discontinuities with a coupled line in between to produce a multiple-line netlist for association with the component. The layout and netlist assigned to a component is shown in **Fig. 3**. The components were used for the design of an LO filter **(Fig. 4)**.

Design of the stubs is also critical to ensure that the LO signal remains in the diodes and is not present in the output signal, which should be purely 2LO±RF. At the mixer input, the 3LO signal will tend to be reflected back and must be restricted, while at the output strong signals will exist at LO and 3LO, which must also be reflected back into the diode. The stubs for these frequencies allow the angle of reflection to be optimized.

Via-hole modeling is an important consideration in the stub design, and Ansoft Designer incorporates many 2D and 3D arbitrary-shaped via holes **(Fig. 5)**. Its cosimulation capability allows custom via holes to be defined with no restrictions on layers or geometry. Spiral inductors on 5-mil alumina are used in this design, and while they have low quality factor (Q), any adverse effect is mitigated by the fact that higher-order products are handled by the stubs and filter.

After the stubs have been created, the circuit can be assembled with the stubs in the intended locations, along with the SMT or chip capacitor, diodes, LO filter, and grounded stub for the DC return **(Fig. 6)**. Various basic performance measurements can then be performed, including output power versus LO input power, output power versus RF input power, output power versus frequency, and harmonic output. The harmonic output measurement reveals that even harmonics are not present, verifying that diode balance is excellent. A 3D plot of IF power versus length and width dimensions shows how varying these parameters affect circuit performance, a comparison that would be difficult to interpret in a 2D plot **(Fig. 7)**.

Ansoft Designer allows the completed mixer to be inserted into another circuit or even a system-level circuit to provide accurate system simulation. The software's system tool automatically extracts the necessary parameters from the mixer circuit for use in the system simulation. MRF

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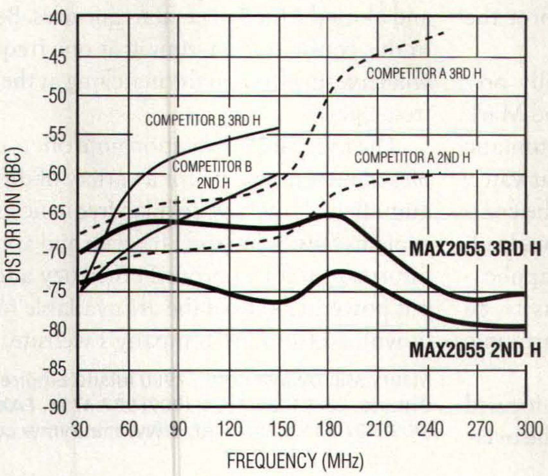
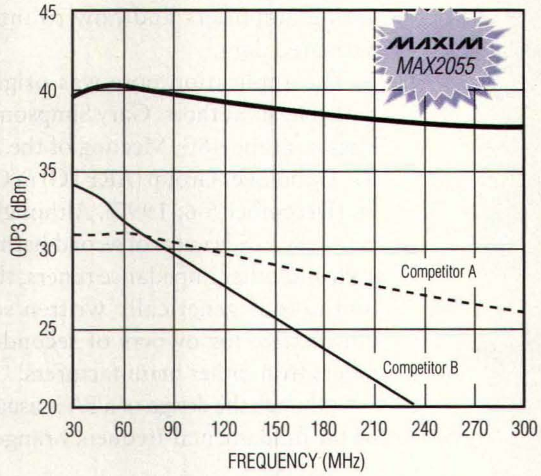
HARMONIC DISTORTION vs. FREQUENCY



OUTPUT IP3 vs. FREQUENCY



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Incorporate second-harmonic tuning in amplifier design

POWER-AMPLIFIER (PA) DESIGN for modern communications systems requires a careful balance between achieving high power and efficiency. One way to achieve effective high-power amplifier designs is through the use of impedance tuners to determine the optimum matching conditions for maximum power and efficiency. An application note from Maury Microwave (Ontario, CA), "Importance of 2nd harmonic tuning for power amplifier design," explains how to set up a measurement system for evaluating amplifiers and how to interpret the measured data.

The application note was originally presented by its authors, Gary Simpson and Mark Vassar, at the 48th Meeting of the Automatic RF Techniques Group (ARFTG) in Clearwater, FL (December 5-6, 1997). Although the company sells a wide range of second-harmonic, load-pull, and other impedance tuners, the application note is generically written so as to be informative for owners of second-harmonic tuners from other manufacturers.

Although the design of a PA is usually focused on the fundamental-frequency range, the overall performance can be significantly affected by tuning at the harmonic frequencies. During measurements of these harmonic effects, extra impedance tuners are usually added to a measurement setup to allow independent load tuning at the harmonic frequencies. In a typical test setup, the signal path from the device under test to the fundamental tuner will pass the fundamental frequencies and block the harmonic frequencies, while the signal path from the harmonic tuner will pass the harmonic frequencies and block the fundamental frequencies. Because of this configuration, tuning at one frequency will have no effect on the matching at the other frequency.

The five-page application note offers examples of measured data for a variety of different amplifiers, largely at cellular frequencies, and explains how to interpret the data and apply the information for improved efficiency and output power. Copies of the are available for free download from the company's website.

Maury Microwave Corp., 2900 Inland Empire Blvd., Ontario, CA 91764-4804; (909) 987-4715, FAX: (909) 987-1112,, Internet: www.maurymw.com.

One way to achieve effective high-power amplifier designs is through the use of impedance tuners to determine the optimum matching conditions.

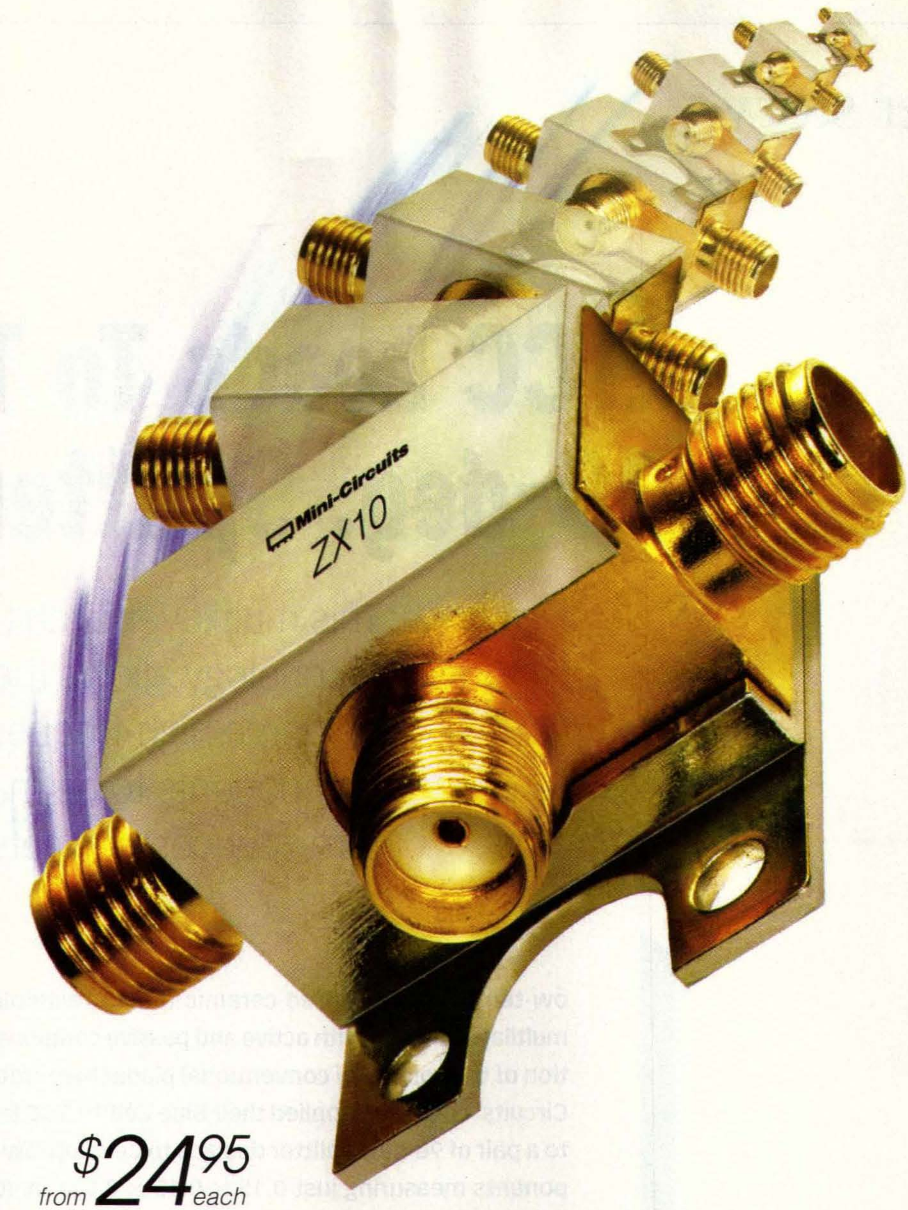
Selecting antennas for wireless-communications base stations

WIRELESS-COMMUNICATIONS SYSTEMS RELY on antennas at both mobile units and base stations to effectively transfer voice, data, and video information. Selecting an antenna for a base station is particularly critical, since a single base station may serve a large number of mobile units. Fortunately, those tasked with specifying antennas for base stations can find much useful guidance in an application note from Decibel Products (Dallas, TX), "Engineering of Wireless Communications Antenna Systems."

This lengthy (more than 18 pages) application note offers a variety of different sections on engineering and specifying base-station antennas, including chapters on electrical and mechanical characteristics, sections on understanding materials in different environments, and troubleshooting techniques. In the section on "Electrical Characteristics," for example, antenna radiation patterns are defined as a function of coverage area or azimuth plane. Various antenna patterns are plotted in different configurations (with an antenna in the center or with an antenna off-center) in order to provide either omnidirectional radiation patterns or shaped patterns. This portion of the application note also provides details on understanding antenna polarization, gain, VSWR and impedance, and bandwidth.

The section on "Mechanical Characteristics" points out the importance of selecting a proper mounting location and configuration in terms of operating life and serviceability. This section includes a wind-load graph to show the how to calculate the effects of different wind velocities on wind loading when the projected area of an antenna is known. The note mentions that an antenna should be designed/installed to withstand winds of at least 100 mph and sometimes more, depending upon the location.

Decibel Products, 8635 Stemmons Freeway, Dallas, TX 75247-3701; (800) 676-5342, (214) 631-0310, FAX: (800) 229-4706, FAX: (214) 631-4706, Internet: www.decibelproducts.com.


Mini-Circuits
ZX10

cover story

LTCC Leads To Tiny 90-deg. Splitter

This multilayer circuit-fabrication technology allows these traditionally large high-frequency passive components to be made in miniature, low-cost formats.

ENGINEERING DEPT.
Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235; (718) 934-4500, FAX: (718) 332-4661, Internet: www.minicircuits.com

Low-temperature-cofired-ceramic (LTCC) technology makes possible multilayer circuits with active and passive components occupying a fraction of the volume of conventional planar high-frequency circuits. Mini-Circuits' engineers applied their Blue Cell™ LTCC fabrication techniques to a pair of 90-deg. splitter designs to develop low-cost packaged components measuring just 0.15 × 0.15 × 0.027 in. (0.381 ×0.381 × 0.69 cm) but with high isolation and low insertion loss from 1200 to 2500 MHz.

The two new 90-deg. splitters are the models QCC-20 **(Fig. 1)** and QCC-22, with frequency ranges of 1200 to 2200 MHz and 1500 to 2500 MHz, respectively. These components are also known as quadrature couplers due to the 90-deg. difference in phase between the two output ports. This type of splitter is generally characterized by means of several parameters, including isolation between ports, insertion loss, phase unbalance between output ports, amplitude unbalance between output ports, VSWR or return loss, and power-handling capability.

The isolation between a two-way power splitter's output ports is evaluated by measuring the attenuation between the two ports when the common (input) port is terminated in 50 Ω (or the characteristic impedance of the system, which can be 75 Ω in video setups). The QCC-20 power splitter, for example, achieves at least 25 dB minimum midband (1400 to 1800 MHz) isolation of 25 dB **(see table)**, with typical midband isolation of 35 dB **(Fig. 2)**. The QCC-22 boasts typical isolation of 23 dB from 2200 to 2500 MHz, with typical isolation of 25 dB from 1500 to 1700 MHz and 28 dB from 1700 to 2200 MHz. The minimum isolation is 17 dB from 2200 to 2500 MHz, 20 dB from 1500 to 1700 MHz, and 23 dB from 1700 to 2200 MHz.

The insertion loss in a two-way power splitter is actually a measure of the amount of loss above the theoretical value due to power division. In an ideal two-way splitter, for example, the two output signals would be one-half the value (3 dB lower)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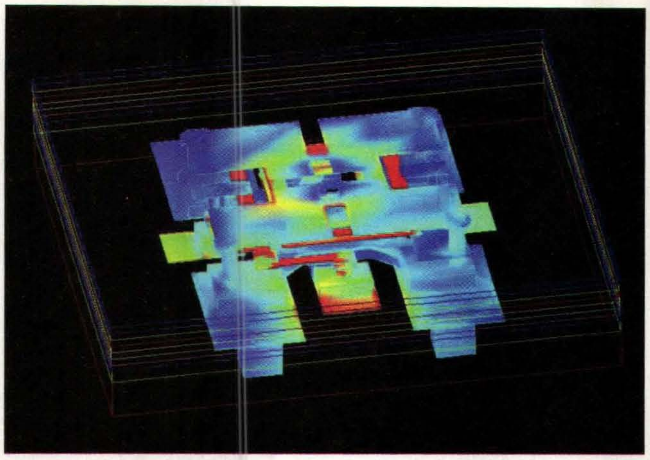
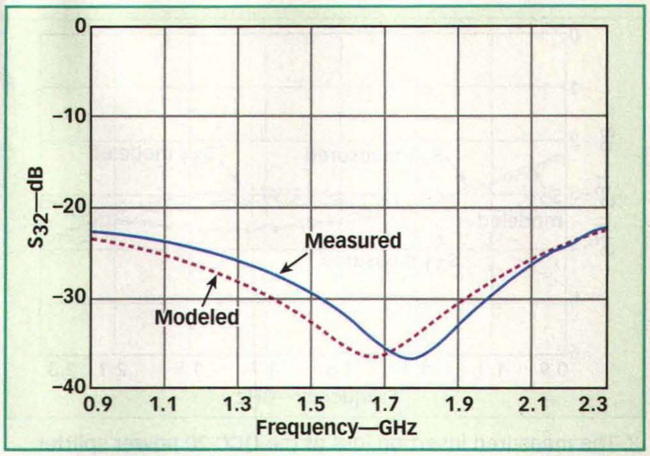


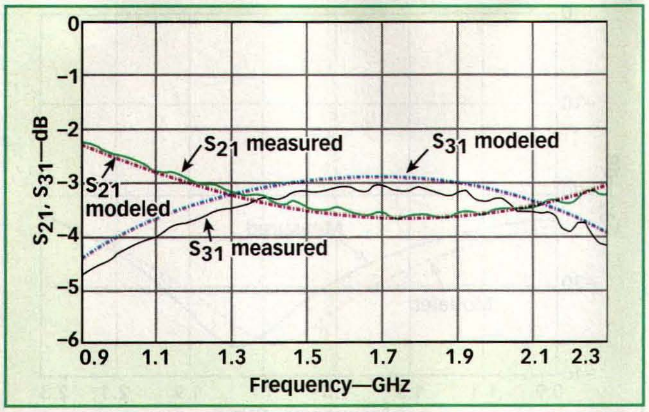
1. This three-dimensional view of the new LTCC two-way power splitters shows the current distribution expected according to computer-aided-engineering (CAE) electromagnetic (EM) analysis.



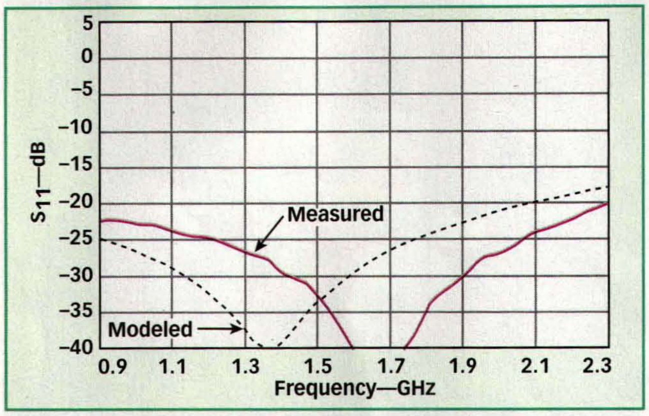
2. The measured isolation of the QCC-20 power splitter (solid line) is compared with the modeled performance (dotted line) from 900 to 2300 MHz.

of the applied input signal. The actual insertion loss in a two-way power splitter is the amount of signal lost (due to resistive losses, circuit impedance mismatches, and other factors) in addition to the theoretical 3-dB division loss. For example, the maximum midband insertion loss (the average of the two output powers minus the 3-dB theoretical division loss) for the QCC-20 is 0.7 dB while the typical midband insertion loss for this splitter is 0.4 dB. At lower and higher frequencies, the insertion loss is slightly lower and higher, respectively **(Fig. 3)**.

The QCC-22 offers the small size of the QCC-20 power splitter for applications requiring slightly higher frequencies, from 1500 to 2500 MHz. The QCC-22 features typical isolation of 25 dB from 1500 to 1700 MHz, with minimum isolation of 20 dB across that band. The typical isolation is 23 dB across the full frequency range, with minimum fallband isolation of 17 dB. The typical insertion loss is 0.4 dB



3. The measured insertion loss of the QCC-20 power splitter (solid lines) is compared with computer-simulated performance (dotted lines).

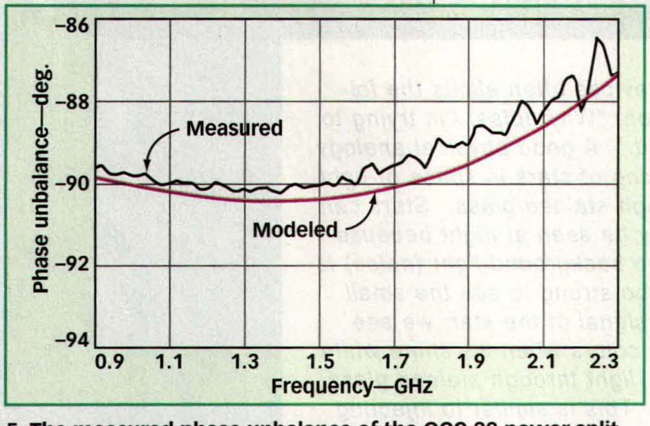


4. The measured return loss of the QCC-20 power splitter (solid line) is compared with CAE simulation data (dotted line) from 900 to 2300 MHz.

from 1500 to 2200 MHz, while the typical insertion loss is a mere 0.5 dB from 2200 to 2500 MHz. The maximum insertion loss is 0.8 dB across the full frequency range of the QCC-22 power splitter.

These power splitters make full use of the company's Blue Cell™ multilayer LTCC technology to achieve full-sized performance in a fraction of the size of traditional microstrip and stripline circuits. LTCC circuits are fabricated by laminating unfired ceramic tapes with printed conductor lines as well as passive circuit elements, such as inductors and capacitors, and then firing the tapes at a temperature between +850 to +875°C to form miniature circuits. Although shrinkage in the ceramic tape occurs in the x, y, and z axes during the firing process, newer LTCC materials minimize and make more predictable the amount of shrinkage, thus increasing final yields of fabricated LTCC products. By reducing the circuit area and tightly controlling their LTCC process, the engineers at Mini-Circuits have developed this pair of chip-sized power splitters at a fraction of the cost of conventional power splitters.

The basic packaging concept for the power splitters had already been developed for a line of LTCC filters,[1] and showed good port match for frequencies through 6 GHz. By modifying that basic package design, a four-port version of the package was created for couplers and power splitters. One additional requirement was a top-side ground to reduce sensitivity to the external electrical environment **(Fig. 4)**.



5. The measured phase unbalance of the QCC-20 power splitter (solid line) compares closely with the computer-modeled values referenced to 90 deg.

Because of their small size, the new power splitters offer outstanding phase and amplitude balance between their output ports. The QCC-20 and the QCC-22 manage to keep the unbalances at the highest frequencies to no worse than 4 deg. For example, the phase unbalance of the QCC-20 is typically 1 deg. and no worse than 3 deg. from 1200 to 1800 MHz, and typically 1 deg. and no worse than 4 deg. from 1200 to 2200 MHz **(Fig. 5)**. The phase unbalance of the QCC-22 is typically 2 deg. from 1500 to 2500 MHz with worst-case phase unbalance of 4 deg. across that frequency range.

The amplitude unbalance for the QCC-20 is typically 0.5 dB from 1200 to 2200 MHz, with maximum amplitude unbalance of 1 dB. The amplitude unbalance for the QCC-22 is typically 0.6 dB or better from 1500 to 2500 MHz.

These first-generation LTCC power-splitter designs are available for use from 1200 to 2500 MHz, with soon-to-be-announced models available for lower and higher frequency ranges. The power splitters, which are designed to handle input power levels as high as 5 W (+37 dBm), are rated for operating temperatures from –55 to +100°C. **Mini-Circuits, P.O. Box 350166, Brooklyn, NY 11235; (718) 934-4500, FAX: (718) 332-4661, Internet: www.minicircuits.com.**

Specifications of the splitters

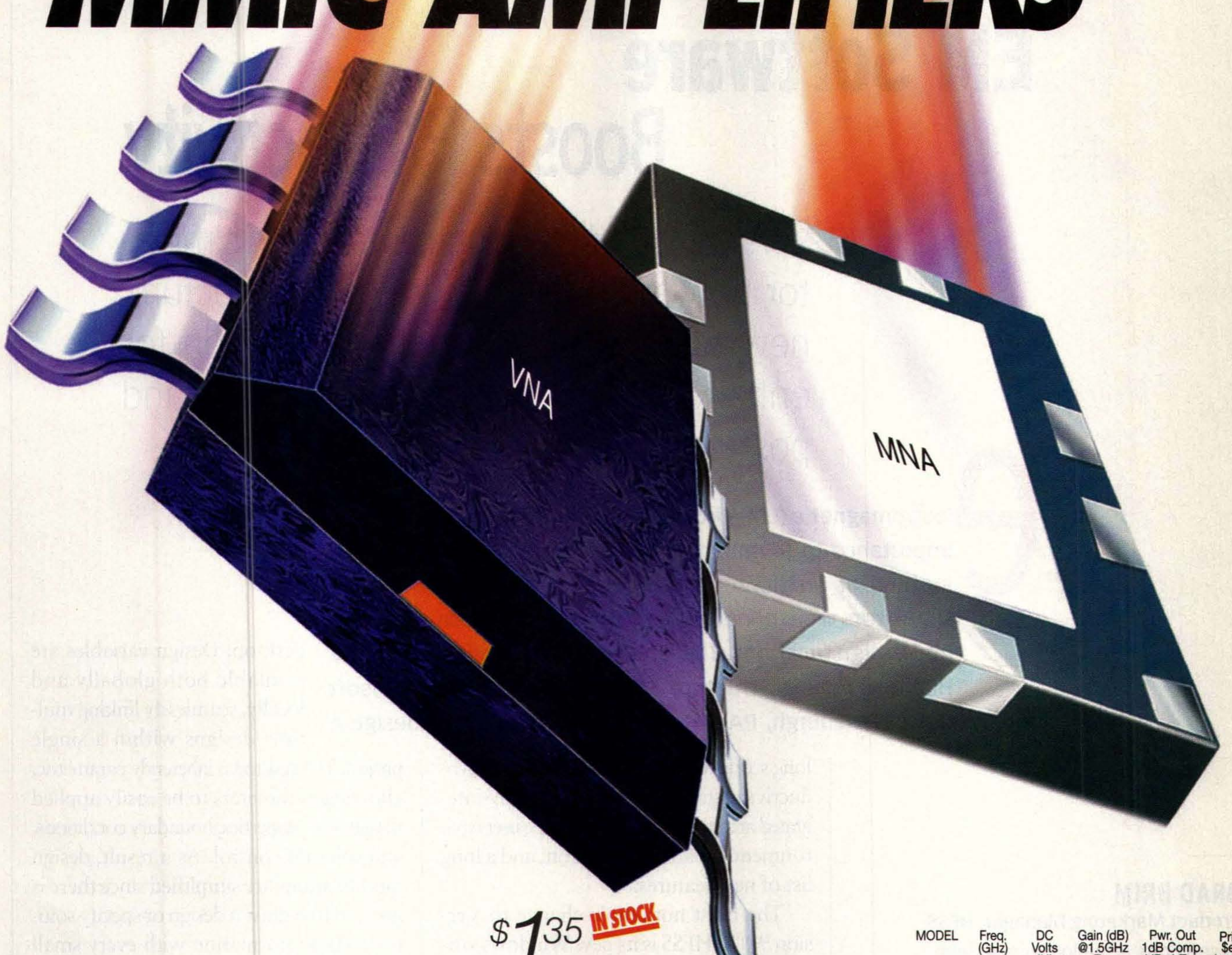
MODEL	FREQUENCY RANGE (MHz)	ISOLATION (TYP.) (dB)	INSERTION (TYP.) (dB)	PHASE UNBAL. (deg.)	AMPLITUDE UNBALANCE (dB)
QCC-20	1200 to 1400	32	0.4	1	0.4
	1400 to 1800	35	0.4	1	0.4
	1800 to 2200	23	0.6	1	0.5
QCC-22	1500 to 1700	25	0.4	2	0.6
	1700 to 2200	28	0.4	2	0.2
	2200 to 2500	23	0.5	2	0.3

REFERENCE

1. Data sheets for NYLFTC and HFTC series filters, Mini-Circuits, Brooklyn, NY, www.minicircuits.com.

500MHz-5.9GHz

MMIC AMPLIFIERS



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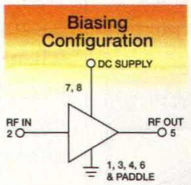

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ACTUAL SIZE

MODEL	Freq. (GHz)	DC Volts (V)	Gain (dB) @1.5GHz Typ.	Pwr. Out 1dB Comp. (dBm) Typ.	Price $ea. (qty.30)
MNA-2	0.5-2.5	5.0 2.8	12.8 11.2	17.7 12.9	1.90
MNA-3	0.5-2.5	5.0 2.8	16.1 15.0	11.4 9.7	1.60
MNA-4	0.5-2.5	5.0 2.8	16.4 14.5	19.0 13.4	1.90
MNA-5	0.5-2.5	5.0 2.8	21.9 20.5	12.2 10.1	1.60
MNA-6	0.5-2.5	5.0 2.8	23.6 21.2	18.0 14.1	2.25
MNA-7	1.5-5.9	5.0 2.8	15.9 13.7	15.6 12.7	2.25
VNA-21	0.5-2.5	5.0 2.8	13.5 12.3	8.5 7.0	1.80
VNA-22	0.5-2.5	5.0 2.8	13.8 12.6	17.0 14.0	2.20
VNA-23	0.5-2.5	5.0 2.8	18.3 17.1	10.0 8.5	1.90
VNA-25	0.5-2.5	5.0 2.8	18.6 17.4	18.2 12.0	2.50
VNA-28	0.5-2.5	5.0 2.8	22.8 21.0	11.0 9.6	1.95

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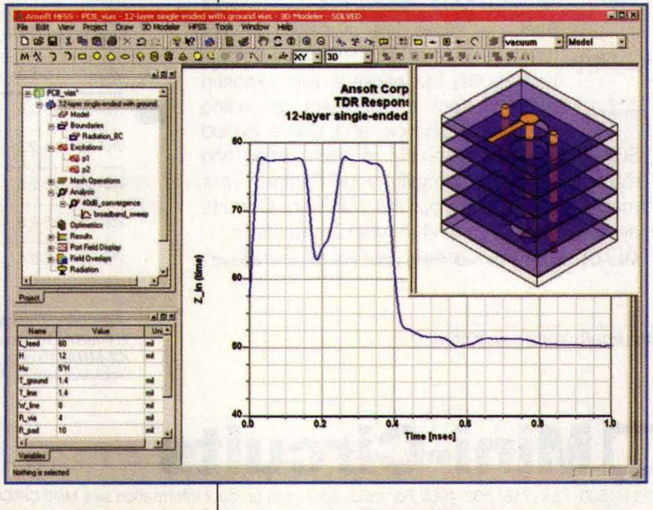
EM Software Boosts Productivity

Version 9.0 of this electromagnetic simulator now sports an integrated architecture, new tools, and improved automation for enhanced design capture, analysis, and post-processing.

Electromagnetic (EM) circuit simulation has grown steady in importance to RF/microwave designers. Long an accurate method of predicting high-frequency behavior, early EM simulators were nonetheless difficult to use because of limited design functions. The latest version (Version 9.0) of the High-Frequency Structure Simulator (HFSS) from Ansoft Corp. (Pittsburgh, PA), however, takes EM-based design a long stride forward to increase design productivity, starting with a new highly-integrated architecture, Windows-type user environment, greater automation, and a long list of new features.

BRAD BRIM
Product Marketing Manager, HFSS
Ansoft Corp., 4 Station Square, Suite 200, Pittsburgh, PA 15219; (412) 261-3200, FAX: (412) 471-9427, e-mail: info@ansoft.com, Internet: www.ansoft.com.

The most noticeable change to Version 9.0 of HFSS is its new Windows-oriented design environment, the Ansoft Desktop. Nearly every function in the process of design capture, analysis, or post-processing can be invoked from this desktop. Design variables are available both globally and locally, seamlessly linking multiple designs within a single project. The desktop is inherently parametric, allowing parameters to be easily applied to material properties, boundary conditions, and solution control. As a result, design modifications are simplified since there is no need to redraw a design or specify solution setup information with every small change. Any design or solution parameter can be examined before or after analysis, and graphical animation allows a parameterized geometry to be visualized when changing physical design parameters. The same parametric display, including field visualization, also is available after analysis is performed.



Three-dimensional (3D) translucency allows this 12-layer PCB viahole to viewed intuitively (the impedance TDR response is shown in the background).

Design capture is more complete and easier to perform in Version 9.0. In addition to 3D geometry generated within the Ansoft Desktop environment, designs created in either a two-dimensional (2D) electronic-design-automation (EDA) layout tool or a 3D mechanical computer-aided-design (CAD) package can be imported, provided the files are industry standard file types (SAT, STEP, and IGES). Ansoft offers an add-on product called AnsoftLinks that allows 2D EDA layout designs to be

imported, creating a direct link to EDA tools from Cadence, Mentor Graphics, Synopsys, and Zuken.

The solid-modeling capabilities in HFSS v9 now include geometric object translucency **(see figure)** along with a "Windows-standard" color palette. Objects can be selected by clicking on them in the solid-modeling window or through an associated history tree, which is a file browser-type display of the geometry, its hierarchy, and its history. The user also has the ability to spin a geometry, giving the model a constant angular rotation so that all sides can be seen.

The local coordinate system of an object is easily associated with an existing face in the geometry in Version 9.0, allowing designers to intuitively draw "stacked" objects. When an object is selected, its properties may be edited in a window or dialog box. These properties include materials, color, and geometric parameters.

Version 9.0 of HFSS allows multiple objects to be selected and their common attributes edited in a single operation. The geometric copy-paste function allows groups of objects to be copied within a design or between separate designs. This operation transfers all user-defined material properties and design variables. All associated boundary conditions and port definitions (including definitions for modes, lines, de-embedding, etc.) as well as entire designs may be copied between projects.

A variety of solution setup options are available to designers in Version 9.0, since designers may want to generate analyses with various levels of accuracy, analyses that are adaptively refined at specific frequencies, or with appropriate seeding densities. A design can include any number of solution setup specifications, and they can be launched as one analysis or as separate analyses. Each setup may have multiple frequency-sweep specifications. For example, a localized frequency sweep may be augmented by a few discrete frequency samples outside this range to sample the high- or low-frequency behavior of a band-limited design.

Analysis setup and control are intuitive, and all configuration and control parameters are accessible from within the Ansoft Desktop. The total number of adaptive solution refinement passes can be specified as well as a minimum number, or the number of consecutive adaptive refinement passes at a particular accuracy level that defines adequate convergence.

To accommodate the broadband behavior of circuit-board materials such as FR4, Version 9.0 of HFSS allows arbitrary frequency dependence to be specified. The same is true for thin-film resist materials, which are handled with frequency-dependent boundary condition specifications. The ability to add frequency dependence to existing surface-based thin layer material approximations makes it possible to determine the broadband behavior of thin dielectric layers or coatings.

Ansoft has also integrated its Optimetrics parametrics and optimization engine into the Ansoft Desktop. Optimetrics performs statistical analyses, parametric sweeps, optimization, and sensitivity studies. Statistical analysis along with sensitivity studies provide insight into the performance of fabricated designs, which is well suited to automated design refinement and design-for-manufacturing approaches.

Version 9.0 of HFSS offers expansive post-processing capabilities. General reports plot frequency-swept data and parameter-swept responses as S-parameter results, characteristic impedance and propagation constants, and Y- and Z-parameters. Data is easily manipulated by built-in equations to generate derived quantities that are easily specified prior to analysis and are available for use as optimization goals. Arbitrary families of traces may be displayed on the same plot. Two-dimensional (2D) data can be extracted from arbitrary n-dimensional, swept-parameter data and displayed as families of traces or as 3D color-shaded plots. All 2D reports may be dynamically updated as solutions are performed, which allows arbitrary convergence data to be viewed as analyses are performed.

Version 9.0 allows local and radiated field solutions to be visualized; the program includes many built-in quantities for display of field data, such as magnitudes, individual scalar components, and specific absorption rate (SAR). The displays are all available at individual points, along lines, on surfaces, and within volumes, and new display types and control mechanisms have been added as well. Version 9.0 can also animate any swept variable, frequency or material parameters, and simultaneous geometric and field animations are supported.

Version 9.0 of HFSS makes it simple to export results, including circuit parameters (S-, Y-, and Z-parameters), and impedance and propagation constants, to industry-standard file formats. The model export ability of Ansoft's Full-Wave Spice model (an add-on for HFSS) has been significantly improved, and SPICE models are available for HSpice, PSpice, and general SPICE analysis engines. Convolution-based and pole-zero models, partial fraction expansions, and lumped equivalent circuits are available as well. **Ansoft Corp., Four Station Square, Pittsburgh, PA 15219-1119; (412) 261-3200, FAX: (412) 471-9427, e-mail: info@ansoft.com, Internet: www.ansoft.com.**

Single HBT Amp Drives All WLAN Bands

This InGaP HBT linear power amplifier is designed for 5.15-to-5.35-GHz WLANs, but will also offer excellent performance across the full 4.9-to-6.0-GHz band.

JACK BROWNE
Publisher/Editor

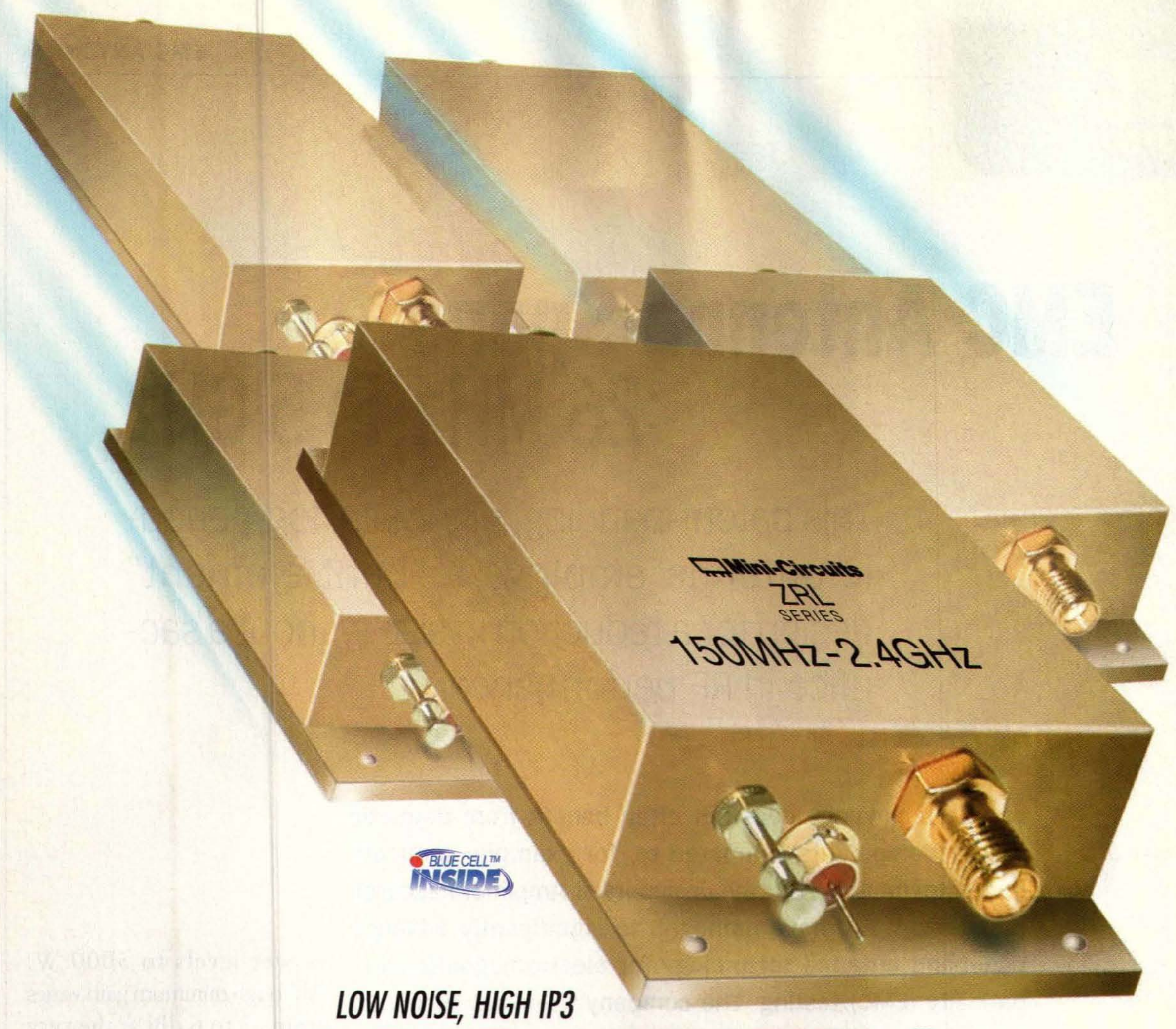
Wireless local-area networks (WLANs) are proliferating almost as fast as the number of WLAN standards. At present, several 5-GHz bands are earmarked for high-data-rate WLANs within the UNII band from 5.15 to 5.85 GHz, including IEEE 802.11a and 802.11g. Normally, a separate power amplifier (PA) would be needed for each WLAN band. But with the availability of the model RMPA5251-251 WLAN PA from Raytheon RF Components (Andover, MA), a single amplifier can now handle all WLAN applications within the 4.9-to-6.0-GHz band.

The RMPA5251-251 is an InGaP heterojunction-bipolar-transistor (HBT) amplifier nominally designed for high-performance WLAN applications from 5.15 to 5.35 GHz. It is also capable of providing high gain and linear output power in the lower UNII band from 4.90 to 5.35 GHz and in the higher UNII band from 5.15 to 5.85 GHz. From 5.15 to 5.35 GHz, the linear PA features 27-dB small-signal gain and +26 dBm (single-tone) output power at 1-dB compression when operating from +3.3-VDC supply.

The PA provides excellent performance with modulated carriers, judging from its error-vector-magnitude (EVM) performance. When evaluated in its low-band (4.90 to 5.35 GHz) configuration for +17-dBm modulated output power in IEEE 802.11a 54-Mb/s operation, there is less than 3.5-percent increase in EVM above the system level. Testing was performed with V_M of +3.3 VDC, V_C of +3.3 VDC, I_C of 188 mA and I_M of 16 mA, assuming a 16.7-MHz channel within the 4.9-to-5.35-GHz band.

The RMPA5251-251 requires only nine additional external components for low-band operation from 4.90 to 5.35 GHz. By changing two external biasing components, the amplifier can be optimized for operation over the full UNII band from 5.15 to 5.85 GHz, with 28-dB single-tone gain, better than 8-dB return loss, +25 dBm single-tone output power at 1-dB compression, EVM of less than 3.5 percent at +18-dBm modulated output power. The PA can also be matched for operation from 4.9 to 6.0 GHz.

The RMPA5251-251 is supplied in a low-profile 16-pin 3 × 3 × 1-mm standard QFN leadless package. For applications requiring amplification of 2.4-GHz IEEE 802.11b signals as well as IEEE 802.11a/g, the company also offers the RMPA2550-252 PA in a 3 × 4 × 1-mm QFN leadless package. Also, the RMPA2453-251 PA is available for just the 2.4-to-2.5-GHz coverage. P&A: $2.50 (RMPA5251-251, 100,000 qty.). **Raytheon RF Components, 362 Lowell St., Andover, MA 01810; (978) 684-5342, FAX: (978) 684-8646, Internet: www.raytheonrf.com.**



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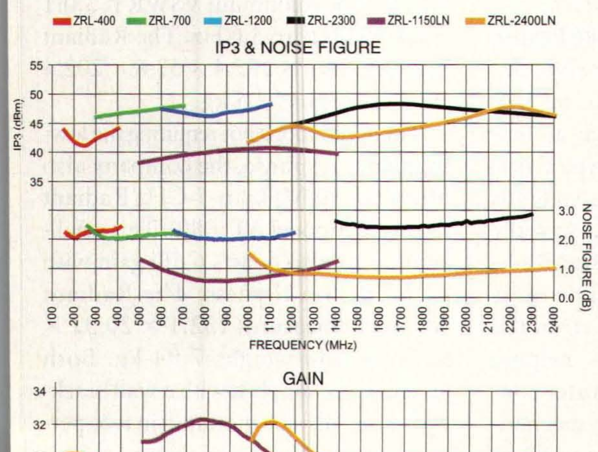

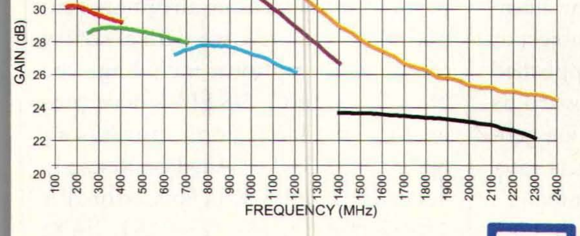

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SPECIFICATIONS (Typical) T=25°C

Model	Freq. (MHz)	Gain (dB)	Noise Fig. (dB)	IP3 (dBm)	Max. Pwr. Out @1dB Comp. (dBm)	Price $ ea. (1-9)
ZRL-400	150-400	30	2.5	42	25.0	119.95
ZRL-700	250-700	29	2.0	46	24.8	119.95
ZRL-1150LN	500-1400	31	0.8	40	24.0	119.95
ZRL-1200	650-1200	27	2.0	46	24.3	119.95
ZRL-2300	1400-2300	24	2.5	46	24.6	119.95
ZRL-2400LN	1000-2400	27	1.0	45	24.0	139.95

DC Power 12V DC, Current 550mA, Dimensions: (L) 3.75" x (W) 2.00" x (H) 0.80"

Detailed Performance Data & Specs Online at: ***www.minicircuits.com/ZRL-SERIES.pdf***

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EMC Antenna Spans 26 MHz To 5 GHz

This patent-pending, high-gain, log-periodic antenna employs a "bent element" design for a reduction in size without a sacrifice in RF performance.

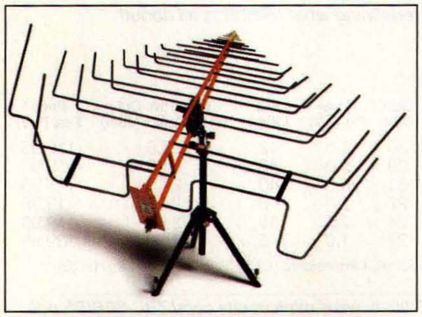
JACK BROWNE
Publisher/Editor

Antenna technology does not often benefit from dramatic new developments compared to, for example, semiconductor technology. But the designers at Amplifier Research (Souderton, PA) have managed to significantly advance wideband antenna technology for electromagnetic-compatibility (EMC) testing. The company's Radiant Arrow 26 (model AT5026) log-periodic antenna uses a unique folded-element design to shrink the size of the antenna without trimming its bandwidth. The Radiant Arrow 26 features a 26-MHz-to-5-GHz bandwidth.

The Radiant Arrow 26 **(see figure)**, which can also be calibrated for EM emissions testing, is ideal for EMC testing. The compact antenna design can accomplish this without need of the typical batwing log-periodic approach that tends to corrupt the electric (E) field, especially in smaller test enclosures. The Radiant Arrow 26 uses the folded elements to keep antenna tips away from the walls of shielded enclosures, helping to reduce reflections. The shorter configuration is significant both mechanically and electrically, resulting in an antenna which is closer to the test object at low frequencies. This is accomplished by bending the elements forward as well as redesigning the standard log-periodic structure to have closer element spacing. Copper heat sinks at the antenna's tip help the new design handle high power levels.

The 50-Ω antenna can handle input power levels to 5000 W. Although minimum gain varies from –3 to 6 dBi at the very lowest frequencies (26 to 80 MHz), the minimum gain of 6 dBi is a relatively flat ±1.5 dB across the majority of the bandwidth, from 80 MHz to 5 GHz. The maximum VSWR is 3.0:1 from 80 MHz to 5 GHz. The Radiant Arrow measures 279.4 × 53.6 × 202.4 cm and weighs 22.5 kg.

For applications not requiring the low-frequency response, the company also offers the 80-MHz-to-5-GHz Radiant Arrow 80 (model AT5080). This smaller antenna also boasts 6 dBi gain with ±1.5 dB gain flatness. The Radiant Arrow 80 measures 132.1 × 20.32 × 97.8 cm and weighs 7.94 kg. Both antennas are supplied with a wall bracket that can also be mounted in two perpendicular planes using an optional tripod. Both are available with a variety of connector options, including type N, C, 7-16, and 1-5/8 EIA female connectors (the latter connector has an upper limit of 3 GHz). **Amplifier Research, 160 School House Rd., Souderton, PA 18964-9990; (215) 723-8181, FAX: (215) 723-5688, e-mail: info@amplifiers.com, Internet: www.amplifiers.com.**



The Radiant Arrow 26 employs a unique folded-element design to provide EMC test coverage from 26 MHz to 5 GHz without E-field distortion in compact test enclosures.

Linearizers Enhance PA Performance

These analog predistortion linearizers can increase wireless amplifier efficiency and linearity while reducing size, cost, and power consumption.

JACK BROWNE
Publisher/Editor

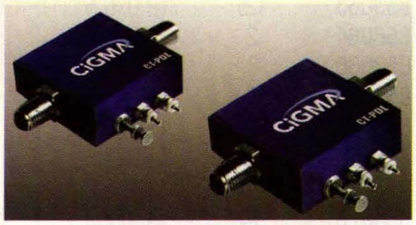
Power amplifiers (PAs) represent one of the more critical components in wireless devices and systems. Many techniques have attempted to improve PA linearity and efficiency, including the use of analog feedforward processing and digital signal processing (DSP). But the elegantly simple predistortion linearizers (PDLs) developed by Cigma Technologies (Allendale, NJ) may offer the best combination of improved efficiency and linearity along with savings in amplifier size, cost, and power consumption. Versions of the PDLs are available for both handset and base-station PAs.

The PDL **(see figure)**, introduced earlier this year (see *Microwaves & RF*, April 2003, p. 33), is essentially a broadband analog circuit that predistorts the amplitude and phase of input signals a PA, so that amplified signals at the PA's output port are highly linear. Because the input signals are optimized, the amplifier can run at high efficiency, and more output power is available from a given design. With greater efficiency, thermal design can be controlled and a smaller amplifier can deliver a desired output-power level.

In general, the base-station PDLs are designed to reduce PA intermodulation distortion (IMD) by as much as 20 dB, and can achieve efficiency as high as 20 percent. They can be used to effective double (increase by 3 dB) usable PA output power, and reduce PA size and cost by as much as 40 percent.

The base-station PDLs are available in bands of 800 to 900 MHz, 1800 to 1900 MHz, and 2400 MHz in three different configurations. The CT-PDL is a basic open-loop (nonadaptive) PDL configuration with some passive circuit loss, but with greater than 14-dB reduction in IMD when applied to single-carrier WCDMA signals. The CT-PDLU is a similar design, but with 0-dB insertion loss. The CT-PDLC is a closed-loop (adaptive) configuration with integral microcontroller.

Like the base-station units, the model CT-PDLH handset PDL is designed to improve PA IMD performance. For a handset, the IMD improvement is applied toward reduced current drain and longer talk time. The CT-PDLH can deliver as much as 50-percent improvement in handset PA efficiency, with a 3-dB increase in handset PA output power and greater than 60-dB dynamic range. The CT-PDLH is available as a discrete device or integrated with a customer's RF integrated-circuit (RF IC) PA. **Cigma Technologies, Inc., 40 Boroline Rd., Allendale, NJ 07401; (201) 818-9300, FAX: (201) 818-0400, Internet: www.cigmatech.com.**



The CT-PDL is the most basic version of the analog predistortion-linearizer (PDL) circuit, for open-loop (nonadaptive) applications in which the gain and phase of signals fed to a PA are optimized for improved PA IMD performance.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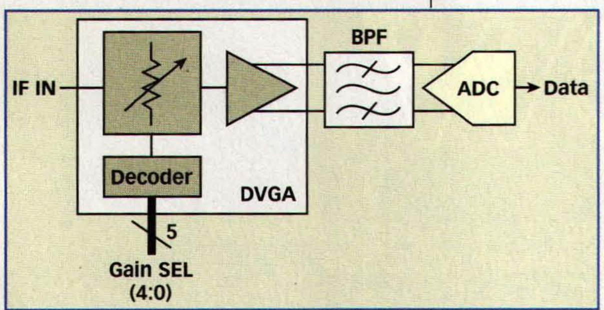
JACK BROWNE
Publisher/Editor

Digitally controlled gain in the new MAX2055 variable-gain amplifier (VGA) from Maxim Integrated Products (Sunnyvale, CA) allows the device to quickly achieve optimum signal levels for analog-to-digital converters (ADCs). Designed for intermediate frequencies (IFs) from 30 to 300 MHz, the MAX2055 is ideal for receivers (Rxs) in a variety of wireless communications standards, including WCDMA, cdma2000, GSM, DCS/PCS, and EDGE.

The MAX2055 **(see figure)** is a highly integrated (total of 325 transistors) amplifier fabricated with a high-speed silicon BiCMOS process. Designed for use with 50-Ω single-ended inputs and differential outputs over a frequency range of 30 to 300 MHz, the amplifier is suitable for gain control of signals entering a high-speed ADC. The MAX2055 integrates a digital attenuator with 23-dB selectable attenuation range (from –3 to +20 dB) and a high-linearity single-ended-to-differential amplifier. The amplifier's gain flatness is ±0.5 dB across a 50-MHz bandwidth.



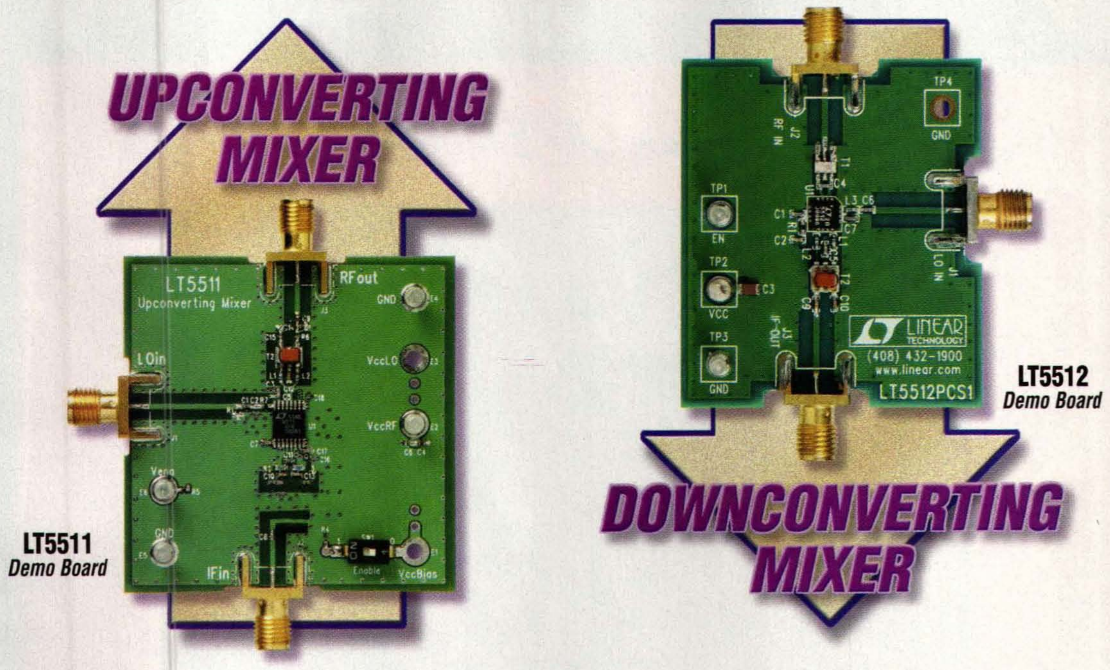
The MAX2055 is a highly integrated single-ended-to-differential driver amplifier with on-board digitally controlled attenuator that is ideal for controlling input signal levels to high-speed ADCs.

The MAX2055's attenuation/gain range is set with 1-dB resolution (and ±0.2 dB absolute accuracy at +25°C) by means of five logic lines. The attenuator switching speed is a mere 40 ns from 50 percent of a control signal to 90 percent of a new RF level. Negative feedback in the amplifier helps achieve high gain and linearity over the wide operating bandwidth. Even over the wide operating temperature range, the gain drift with temperature is typically only ±0.3 dB.

Good low-noise performance and exceptional linearity make the MAX2055 a good choice for broadband communications systems, cellular systems, test equipment, and any application requiring optimal level control of signals feeding a high-speed ADC. The MAX2055 features typical noise figure of 5.8 dB and output 1-dB compression point of typically +25.7 dBm. The well-designed circuit achieved reverse isolation of typically 29 dB, a second-order output intercept point of typically +75 dBm (+5 dBm/tone), and a third-order output intercept point of typically +40 dBm over all gain conditions (+5 dBm/tone).

The MAX2055 is supplied in a 20-pin TSSOP-EP package. It is designed for supply voltages from +4.75 to +5.25 VDC, and it typically draws 240 mA of current. **Maxim Integrated Products, Inc., 120 San Gabriel Dr., Sunnyvale, CA 94086; (408) 737-7600, FAX: (408) 737-7194, Internet: www.maxim-ic.com.**

RF Active Mixer ICs High Linearity, DC-3GHz



IIP3 Up to +21dBm at 950MHz; +17dBm at 1900MHz

Our new LT®5511 and LT5512 are precision up and down-converting active mixer ICs, respectively, which feature "Best In Class" linearity and excellent port-to-port isolation. Reduced external component count and simplified input/output matching make these ICs easy to use. LO drive requirements are greatly eased by an integrated LO driver with single-ended or differential input. Low distortion operation makes these mixers ideal for use in wireless and cable infrastructure as well as RF instrumentation and radio links.

Features

	Upconverter LT5511	Downconverter LT5512
Conversion Gain	0dB	1dB
IIP3 950MHz 1900MHz	+17dBm +15.5dBm	+21dBm +17dBm
IIP2	+52dBm	NA
SSB Noise Figure	15dB	13.3dB
LO-Input Leakage	NA	-53dBm
LO-Output Leakage	-46dBm	-46dBm
LO Drive Level	-15 to -5dBm	-15 to -5dBm
Supply Current	56mA	57mA
Supply Voltage	4V to 5.25V	4.5V to 5.25V
Package	16-Lead SSOP	4mm x 4mm QFN

Data Sheet

www.linear.com/go/5511

Online Store

www.linear.com/lineardirect

More Information

Call: 1-800-4-LINEAR
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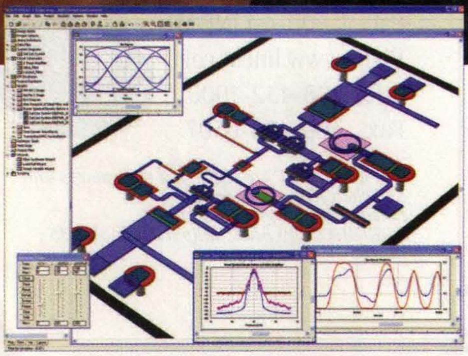

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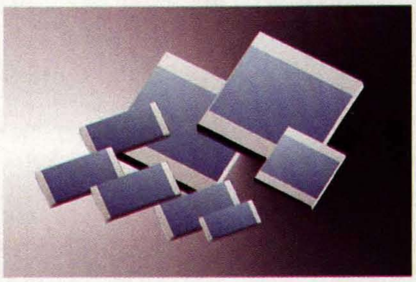
Prototyping System Features Large Work Area

THE QUICK CIRCUIT 9000 allows prototyping of large antenna and back-plane designs as well as providing for all traditional analog and RF circuit-board and prototyping needs. The system features a work area of 19 × 19 in. (480 × 480 mm). The Quick Circuit 9000 includes IsoPro software. This software enables automatic data conversion for most any CAD package. The software allows for "step and repeat" for multiple boards on a panel and includes all machine-driving functionality in a single software package. Over a typical design and development cycle, the Quick Circuit family of systems have proven themselves in allowing cost savings, convenience, and reduced time to market.

T-Tech, Inc., Technology Park, 510 Guthridge Ct., Norcross, GA 30092; (800) 370-1530, FAX: (770) 455-0970, e-mail: info@t-tech.com, Internet: www.t-tech.com.

Chip Resistors Use Thin Film On Aluminum Nitride

A LINE OF MICROWAVE high-power chip resistors utilizing thin film on aluminum nitride (AlNi) is suitable for applications where current noise is a consideration. The components have a maximum power rating over five times higher than conventional chip resistors. The high-power resistors are available in values of 50 and 100 Ω. A variety of case sizes is available from 1206 (0.125 × 0.65 in.) to 3838 (0.375 × 0.375 in.) With available tolerances of ±0.1 percent and a temperature coefficient of resistance to 50 ppm. VSWR is 1.3:1 or better up to 4 GHz. P&A: Pricing starts at $1.19 in production quantities. Current delivery is stock to 9 wks. ARO. Free product samples and data sheets are available on request.



State of the Art, Inc., 2470 Fox Hill Rd., State College, PA 16803-1797; (800) 458-3401, FAX: (814) 355-2714, e-mail: marketing@resistor.com, Internet: www.resistor.com.

Mixers Feature High Linearity Performance

A LINE OF HIGH dynamic range monolithic mixers achieve up to +36 dBm input IP3 for cellular/PCS/3G infrastructure applications. The HMC399MS8 covers 700-to-1000-MHz RF and 60-to-250-MHz IF frequencies for GSM/CDMA-based cellular-transmit or receive-frequency plans. Input IP3 performance of +35 dBm is provided. The HMC400MS8 covers 1.7 to 2.2 GHz RF and 50 to 300 MHz IF frequencies to satisfy many UMTS/PCS transmit or receive frequency plans configured for low-side LO. The input IP3 performance of up to +36 dBm for downconversion and +31 dBm for upconversion, coupled with the high P1dB of the HMC400MS8 rivals traditional hybrid mixers while offering a much smaller standard IC footprint and no DC bias. The HMC402MS8 features input IP3 performance of +31 dBm for downconversion and +27 dBm for upconversion over 1.8 to 2.2 GHz. It is suitable for high side LO GSM/CDMA-based UMTS/3G or PCS applications. This family of MMIC mixers is manufactured using a production GaAs MESFET process and are 100-percent RF tested. P&A: The HMC399MS8, HMC400MS8, and HMC402MS8 do not require any DC bias and are available in plastic surface-mount 8-lead Mini Small Outline Package (MSOP). These products are available from stock for sampling or sale.

Hittite Microwave Corp., 12 Elizabeth Dr., Chelmsford, MA 01824; (978) 250-3343, FAX: (978) 250-3373, Internet: www.hittite.com.

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Tech Center

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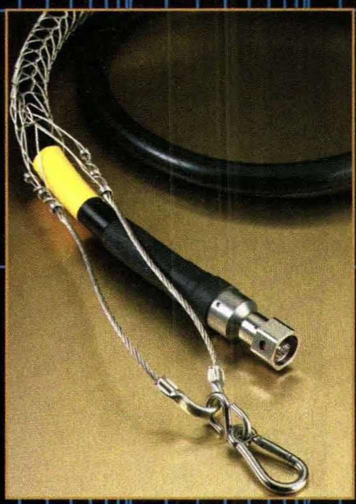
(Quick Erecting Antenna Mast)

Field Deployable Antenna Feeder Cables



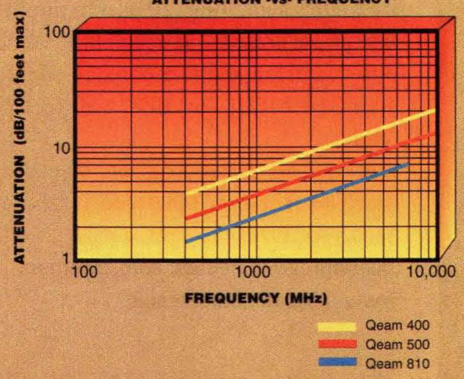
Whether for mission critical military applications or for commercial use, field deployable antenna feeder cables need to be rugged enough to withstand the rigors of repeated reelings, while providing good electrical performance and resistance to a variety of harsh environments. QEAM cable, field proven on the Hawk and Patriot Missile launch systems, is the only cable that meets all these demands.

QEAM antenna feeder cables use an expanded PTFE dielectric, flexible conductors and durable jackets to achieve low bending moment flex life in excess of 10,000 bends on properly selected radii.

Based on the proven designs of Times Microwave Systems' MILTECH aerospace cable assemblies, QEAM assemblies are:

- Completely weather sealed
- Built to MIL-T-81490 requirements
- Corrosion resistant, using heavy duty stainless steel connectors
- Fully tested over specified frequency bands

QEAM SERIES
ATTENUATION -vs- FREQUENCY



QEAM cables are supplied as finished assemblies and may be fitted with hoisting grips and customized to specific military or commercial application requirements.

For rugged field deployable use, where reeling and unreeling durability are required over a wide temperature range, specify the ultimate antenna feeder cable — specify QEAM.

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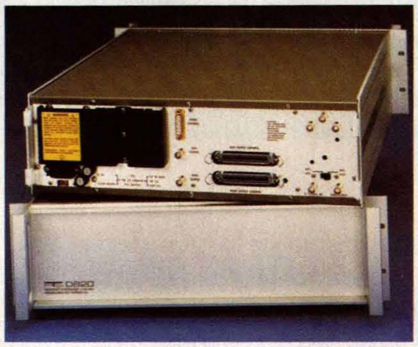
Synthesizer Features Fast Frequency Switching

THE PTS D620 IS A broadband dual-channel frequency synthesizer. The D620 contains two fully independent low-phase-noise, fast-switching frequency synthesizers, each covering 1 to 620



MHz, but housed in the single rack or bench-top form-factor previously occupied by a single synthesizer. For each fully independent channel, frequency control is via a 50-pin parallel interface (TTl-level logic) which is pin and programming compatible with the remote interface standard on current PTS synthesizers. The instruments feature fast frequency switching (20 µs maximum), low phase noise (–110 dBc/Hz at 1 kHz offset), and low spurious output (–65 dBc, 1 to 310 MHz; –60 dBc, 310 to 620 MHz).

Programmed Test Sources,Inc., 9 Beaver Brook Rd., Littleton, MA 01460; (978) 486-3400, FAX: (978) 486-4495, e-mail: sales@programmedtest.com, Internet: www.programmedtest.com.

Programming Suite Performs RF Measurements

AUTOLAB-NF IS THE FIRST part of a series of separate and integrated programming suites for performing RF measurements. Autolab automates common laboratory measurements made on RF and microwave devices and systems. Autolab's object-oriented GPIB system allows test sequences to be abstractly executed with no regard to the actual equipment used to implement the tasks. The programming suite performs noise-figure measurements. The measurements include classic, fast, and small-signal modes. Measurements are made via a spectrum analyzer, of which, virtually all commercially available instruments are supported. The fast mode provides real-time updates of measurement data over the full measurement band, allowing interactive tuning and optimization of circuits and devices.

ARK RF Systems, 1 Cliff Path, Sandown, Isle of Wight PO36 8PN, England; +44(0) 1983 400340, FAX: +44(0) 1983 400345, e-mail: info@arkrfsystems.com, Internet: www.arkrfsystems.com.

Resistors Are Optimized For Microwave Circuits

A SERIES OF THIN-FILM single-value chip resistors feature high-frequency response and low shunt capacitance for suitable performance in hybrid assemblies and microwave and RF circuits. In addition to dimensions as small as 0.010 × 0.020 in. (0.25 × 0.5 mm), the Vishay Electro-Films Microwave Resistor series (MIB, MIC, MID, MIF) features a stripline design that enables the design of higher-performance end products by providing a solution specifically optimized for microwave and RF requirements. Typical applications for new devices include amplifiers, oscillators, attenuators, couplers, and filters. The resistor series devices feature a maximum operating voltage of 100 V, a dielectric breakdown of 400 V, and 25-to-200-mW maximum DC power ratings at +70°C. The thin-film resistor element is tantalum nitride (TaNi), which is self-passivating and moisture resistant. These resistors have an operating temperature range of –55°C to +125°C. P&A: Samples of the MIB, MIC, MID, and MIF chips are available now, with lead times of six weeks for production quantities. Pricing for US delivery for 1-percent tolerance parts in 1000-piece quantities ranges from $0.50 to $1.00, depending on the style.

Vishay Intertechnology, Inc., 63 Lincoln Highway, Malvern, PA 19355-2120; e-mail: info@vishay.com, Internet: www.vishay.com.

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MARKETING AND ADVERTISING STAFF

GROUP PUBLISHER
Craig Roth
(201) 393-6225
e-mail:croth@penton.com

SALES ASSISTANT
Judy Kollarik
(201)393-6218
e-mail: jkollarik@penton.com

DIRECT CONNECTION ADS CLASSIFIED ADVERTISING
Joanne Reppas
(201) 666-6698
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Paul Barkman
Regional Sales Manager
Penton Media, Inc.
611 Route #46 West
Hasbrouck Heights, NJ 07604
(908) 704-2460
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CALIFORNIA, NORTHWEST, SOUTHWEST
Nichole Fox
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45 Eisenhower Dr., fifth floor
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ITALY
Cesare Casiraghi
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GERMANY, AUSTRIA, SWITZERLAND
Friedrich K. Anacker
Managing Director
InterMedia Partners GmbH (IMP)
Deutscher Ring 40
42327 Wuppertal
Germany
Phone: 011-49-202-271-690
FAX: 011-49-202-271-6920

SPAIN
Luis Andrade, Miguel Esteban
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Publicidad Internacional
Sepulveda, 143-38
08011 Barcelona, Spain
Phone: 011-34-93-323-3031
FAX: 011-34-93-453-2977

FRANCE
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Defense & Communication
48 Bd Jean-Jaures,
92110 Clichy
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HOLLAND, BELGIUM
William J.M. Sanders, S.I.P.A.S.
Rechtestraat 58
1483 Be De Ryp, Holland
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FAX: 31-299-671500

CZECH REPUBLIC
Robert Bilek
Production International
Slezska 61, 13000 Praha 3
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Phone: 011-42-2-730-346
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PORTUGAL
Paulo Andrade
Ilimitada-Publicidade Internacional. LDA
Av. Eng. Duarte Pacheco
Empreedimento das Amoreiras-Torre 2
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1070 Lisboa, Portugal
Phone: 351-1-3883176
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TAIWAN, R.O.C.
Charles C.Y. Liu, President
Two-Way Communications Co., Ltd.
11F/1, No. 421
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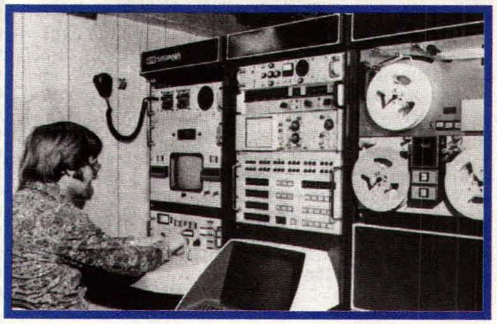

MORE THAN 25 years ago, a news report announced the Federal Aviation Administration's acceptance of a Precision Automatic Tracking System (PATS) from GTE Sylvania (Mountain View, CA). The laser-based system pinpointed targets within ±1 foot at 20 nautical miles.

next month

Microwaves & RF July Editorial Preview

Issue Theme: Amplifiers & Oscillators

News

High-power transistors are the building blocks of high-frequency transmitters, in radars, electronic-warfare (EW), and commercial and military communications systems. As device developers continue to explore the capabilities of less-traditional semiconductor materials, such as silicon-carbide (SiC) and gallium-nitride (GaN), improvements in automated assembly techniques have also contributed to enhanced performance from RF and microwave power transistors. A Special Report in July will highlight some of the latest advances in high-power RF and microwave transistors, including an exclusive report from the GaN laboratories of BAE Systems.

Design Features

Design Features in July will explore some proven techniques for converting distributed microwave-integrated-circuit (MIC) designs to lumped-element monolithic-microwave-integrated-circuit (MMIC) designs. Example circuits include a 90-deg. hybrid coupler and a Wilkinson power combiner/divider. Additional technical articles cover a unique GSM power amplifier with integrated power-control circuitry that directly detects the amplifier's output power and adjusts bias to the transistors accordingly, and a technique for measuring adjacent-channel-power (ACP) dynamic range with a spectrum analyzer. Also, an author from Paradigm Wireless Systems explores noise-mixing effects in high-power amplifiers (HPAs), while authors from Keithley provide guidelines for constructing an effective RF/microwave switching system.

Product Technology

July offers a first look at a single rack-mount instrument capable of generating noise and interference for Global Positioning System (GPS) receiver testing. Designed for both L1 and L2 GPS receivers, the tester offers flexible control of noise and interference signals in order to optimize receiver sensitivity. Additional product features review a line of path-fade simulators for checking signal propagation effects on microwave links, a line of millimeter-wave amplifiers based on novel spatial-combining techniques, a series of microwave training courses on CD-ROMs, and a line-up of high-performance packages suitable for MEMS devices.

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